ELECTRICAL ENGINEERING

NOVEMBER 1957
Vol. 76, No. 11

Published monthly by American Institute of Electrical Engineers

THE COVER: Twin Disc Clutch Company's new research and development laboratory showing the 1,000 hp dynamometer bay. The automatic test machine is instrumented with Baldwin SR-4 devices which permit direct plotting of performance curves in less time. Story appears on page 1026.

Contents

Operating the Hanford Reactors — *D. S. Lewis*
Discussion of personnel requirements, operating procedures, and maintenance problems of a Hanford reactor, based on 13 years' operating experience 951

The Economics of Component Parts Selection — *E. F. Fuegel*
Economic factors involved in the manufacture of equipment designed to meet one or more of three broad categories of requirements 958

International Activities in Insulation Temperature Classification — *L. J. Berberich, K. N. Mathes*
A discussion of the new approach to insulation classification brought about by the advent of new synthetic materials 962

Video Testing Techniques in Television Broadcasting — *A. Ste-Marie*
The practical effects on signal degradation of the parameters in a video transmission system are detailed and discussed 968

Telemetering in Earth Satellites — *Whitney Matthews*
Magnetic telemetry encoding system using a new instrumentation technique combining square hysteresis loop cores with switching transistors 976

The Digital Computer and Power System Short-Circuit Calculations — *M. J. Lantz*
A means has been developed for precalculating short-circuit currents in a power system by the use of a digital computer 981

Insulation Phenomena of Compressed Air — *L. D. McConnell*
Methods used in the location, analysis, and correction of various insulation breakdown phenomena are discussed in this article 984

Color and Monochrome Cathode-Ray Tube Performance Tests — *C. F. Otis*
Many of the problems involved in setting up definitive performance tests for cathode-ray tubes are discussed 990

CONTENTS CONTINUED

ELECTRICAL ENGINEERING: © Copyright 1957 by the American Institute of Electrical Engineers; printed in the United States of America; indexed annually by the AIEE, weekly and annually by *Engineering Index*, and monthly by *Industrial Arts Index*; abstracted monthly by *Science Abstracts* (London). Address changes must be received at AIEE headquarters, 33 West 39th Street, New York 18, N.Y., by the first of the month to be effective with the succeeding issue. Copies undelivered because of incorrect address cannot be replaced without charge.

ALUMINUM-SHEATHED CABLES

...light ...strong ...smaller diameter

A seamless aluminum sheath over Okonite cables provides a durable, conduit-type covering of high tensile strength. Yet this aluminum sheath is easily worked with standard conduit tools. It can be bent around obstructions . . . terminated at boxes, transformers, and the like . . . trained in trays . . . or supported by conventional brackets and cable clamps. Standard fittings are available. This low-cost alternate to rigid conduit is available with virtually any Okonite insulation such as rubber, plastic or varnished cambric.

Here are some important benefits of Okonite's aluminum-sheathed cables:

Reduced diameter and lighter weight.

Impervious barrier to liquids and vapors.

Excellent flame resistance.

Costs less than regular conduit installations.

Great mechanical strength, yet easily worked.

For complete data on Okotherm-insulated (silicone rubber compound) aluminum-sheathed cable for use in high ambients up to 200C (392F), contact your Okonite representative or write for Bulletin EG-1088A, The Okonite Company, Passaic, N. J. 4742

where there's electrical power . . . there's **OKONITE CABLE**

Contents Continued

Technical Paper Digests

Magnetic Amplifier Step Regulator	*Bryan Webb, Jr., G. D. Throop*	957
The Trans-Canadian Microwave System	*S. Bonneville*	967
Electric Analog Circuits for Exact Economic Dispatch	*R. B. Shipley*	974
Radio Frequency Spectrum Management	*C. M. Brant*	975
Quality Assurance	*I. O. Karraker*	988
Internal Corona Spaces in Cables	*D. W. Kitchin, O. S. Pratt*	989

Departments

Institute Activities	996
A Message to the Individual Section Member on "Membership Month"	996
Richland Section Serves as Host to 1957 Pacific General Meeting of AIEE	996
AIEE Future Meetings	999
AIEE Winter General Meeting Scheduled for February 2-7, 1958	1000
Conference Planned on Electrical Techniques in Medicine and Biology	1001
AIEE Mexico Section Celebrates 35th Anniversary	1008
Committee Activities	1010
AIEE Personalities	1011
Obituaries	1012
AIEE Section and Student Branch Meetings, 1956-57	1013
Membership	1015
Electrical Engineering Education	1017
AIEE in Laval University	1017
An Electrical Engineer in Industry	1019
Changes Predicted in the Education of Engineers	1020
Of Current Interest	1025
Electricity from Chemical Energy of Gases	1025
Dynamometer Plots Performance Curves Automatically	1026
Future Meetings of Other Societies	1027
Liquid-Hydrogen Bubble Chamber Developed	1029
Nuclear Developments	1030
"Signal Enhancement" Increases Radar Power Effect	1033
Experimental 60-Kc Standard Frequency Broadcast	1034
New Books	1039
Technical Literature	1040
Industrial Notes	18A
New Products	36A
Trade Literature	74A
Index to Advertisers	88A

Charles S. Rich
Editor and Manager of Publications

G. C. Baxter Rowe
Associate Editor

Editorial Assistants
A. M. Fallert
E. Reichman
V. S. Tavitian
S. Walters
R. E. Whitlock

J. S. Lopes
Central Advertising Director

J. S. Holzer
Eastern Advertising Director

A. E. Del Gado
Mid-West Advertising Director
1604 Chicago Ave., Evanston, Ill.
Tel.: University 4-5353

T. P. Galavan
A. O. Dillenbeck, Jr.
West Coast Adv. Office
266 South Alexandria Ave.
Los Angeles 4, Calif.
Tel.: DUnkirk 5-3991

Waldo Schraubstader
Market Research Director

M. R. Rodgers
Advertising Production Manager

ABC
Member
Audit Bureau of Circulations

Statements and opinions given in articles appearing in *ELECTRICAL ENGINEERING* are expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on controversial matters. Published monthly by the

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Founded 1884

Headquarters, 10th floor • Editorial Offices, 6th floor

33 West 39th Street, New York 18, N. Y.

W. J. BARRETT, President N. S. HIBSHMAN, Secretary

PUBLICATIONS DEPARTMENT: L. R. Gaty, *Chairman* H. N. Muller, Jr., *Vice-Chairman* C. S. Rich, *Secretary*
E. W. Boehne D. T. Braymer C. E. Dean L. K. Del Homme W. F. Denkhaus
E. I. Green E. T. B. Gross W. R. Harris W. Scott Hill C. W. Leiby F. C. Roberts J. D. Tebo

ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office Hildreth Press, Bristol, Conn. Editorial and advertising offices 33 West 39th Street, New York 18, N. Y. Member subscription $6 per year nondeductible from dues; single copy 75 cents. Nonmember subscription $12 per year plus extra postage to all countries to which second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Bristol, Conn. under the Act of Congress of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P. L. & R. Act of February 28, 1925. November 1957. Vol. 76, No. 11. Number of copies this issue, 63,000.

glass-base laminates?

C-D-F DILECTO®

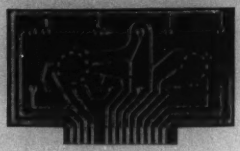
is the answer!

Teflon*, silicone, epoxy, melamine, and phenolic glass-fabric laminates. Polyester glass-mat laminates.

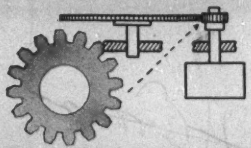
You can improve design, speed production, and save money by specifying one of the many C-D-F Dilecto grades. Whatever your application for these laminates — with fine- or medium-weave glass-cloth base — you'll find a better answer to your problem at C-D-F. (Melamine can also be made with glass-mat base.) And C-D-F offers modern machining and fabrication facilities to deliver production quantities of finished Dilecto parts to your specifications.

See our catalog in Sweet's Product Design File, where the phone number of your nearby C-D-F sales engineer is listed. For free trial samples of glass-base Dilecto, or of any other C-D-F plastics, mica, or fibre product, send us your print or your problem! Write for your free copy of C-D-F Technical Bulletin 64.

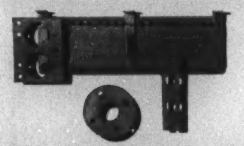
*DUPONT TRADEMARK FOR TETRAFLUOROETHYLENE RESIN



SPEED AUTOMATIC PRODUCTION of printed circuits with warp-resistant C-D-F metal-clad Teflon* and epoxy laminates. Other advantages: high bond strength of copper to laminate, superior blister-resistance in solder immersion.



HIGH-VOLTAGE (1800v.) RF ISOLATION is achieved by miniature C-D-F Dilecto gears in an aircraft receiver-transmitter switch. They also had to exhibit dimensional stability through a wide temperature range, resistance to fungus growth and thermal shock.



PRECISE MACHINING AND FABRICATION are standard benefits of Dilecto laminated plastics. These silicone glass-base parts (coil mountings, aircraft terminal board) were sawed, drilled, punched, and milled in production quantities by C-D-F and customer.

PROPERTIES OF SOME TYPICAL C-D-F DILECTO GLASS-BASE GRADES

Grade	Equivalent NEMA or ASTM grade	Flexural Strength Lengthwise (PSI)	Dissipation Factor at 10⁶* Cond. A	Dielectric Strength Parallel Step x step	Insulation Resistance Cond. C96/35/90	Arc Resistance (seconds)	Maximum Operating Temp. (°C.)
GB-112T (Teflon*)	None	14,000	0.0015	65	100,000	180+	250
GB-12S (Silicone)	G-7	28,000	0.002	60	100,000	180+	200
GB-28E (Epoxy)	G-10	70,000	0.019	65	75,000	130	150
GB-28EFR (Flame-Retardant Epoxy)	G-10	68,000	0.010	65	100,000	180	150
GB-28M (Melamine)	G-5	50,000	0.014	50	100	185	135
GB-261D (Phenolic)	G-1 and G-2	22,000	0.020	55	10,000	5	150
GM-PE (Polyester)	GPO-1	35,000	0.020	70	200	130	150

These are typical grades for typical applications. To meet special requirements, C-D-F makes many other Dilecto grades, one of which may serve your purpose better than any of these listed here. Consult the C-D-F Technical Department for expert assistance with your design problem involving laminated plastics products.

CDF

CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Budd COMPANY • NEWARK 86, DELAWARE

For more information circle 2 on reader service card.

Operating the Hanford Reactors

D. S. LEWIS

A considerable amount of valuable information has been obtained as the result of 13 years' operating experience at Hanford. This article, after a brief plant description, discusses personnel requirements, operating procedures, and maintenance problems of a Hanford reactor. The items covered are indicative of the types of problems to be faced by the managers of future nuclear power plants.

THE LARGE production reactors at Hanford, Wash., were originally placed in operation in 1944, and are still operating after 13 colorful and exciting years. Within the rigid security limitations imposed on this vital link in this country's defense, some of the problems of operating these reactors are discussed.

In the latter part of 1944 and the early part of 1945 the orginal three Hanford reactors were placed in operation. During the subsequent years, after World War II, reactor additions were made until, at the present time, there are a total of eight reactors operating at Hanford. Despite increasing maintenance problems, the three original reactors are still operating. Their production rates are several times greater today than original design specifications. Continual improvements have been made and are continuing to be made in operating methods, procedures, and techniques. These improvements have resulted in a steady increase in production accompanied by a steady decrease in product cost.

DESCRIPTION OF A TYPICAL REACTOR AREA

A TYPCIAL HANFORD REACTOR (the original name was Pile) is a graphite-moderated, water-cooled reactor using natural uranium slugs for fuel. It is designed solely for plutonium production, and cooling water is used on a once-through basis. Except for a small facility at one of the more recent plants, which recovers sufficient heat to provide space heating for the area buildings, no power recovery is made.

A typical reactor area is located along the banks of the Columbia River. A river pump house pumps water to the water treatment plant. Each water treatment plant has complete facilities for filtering the water, providing reserve storage, and adding the proper chemicals to give cooling water to the reactors in the desired quantities and at the desired water quality. The water is pumped through the reactor where it becomes slightly irradiated and removes reactor heat. It then flows into a retention system where it is held until suitable radioactive decay and thermal cooling has taken place to allow it to be returned to the river. Power for the area is supplied by the Bonneville Power Administration. Each reactor plant area has its own coal- or oil-fired steam generating plant which provides emergency steam back-up to generate electricity or operate pumps in the event of a power failure. Each area has its own laboratory, offices, and shops. Each area is surrounded by a security fence and has a roving guard force. There are several miles between individual reactor areas. Some facilities, such as fire apparatus and many of the plant services, are shared with other reactor areas.

PERSONNEL REQUIREMENTS

OPERATING REACTORS is very similar to operating a chemical process. Although there are no poisonous chemicals or corrosive fluids that require special precautions, radiation precautions are necessary for the safety of employees. These safety measures tend to complicate reactor operations and present problems which are not encountered in other industries. When the first reactors were started up, the operating crews were manned mostly with supervisory and engineering personnel. As operating experience grew, more and more trained operators were absorbed into the work force, and the number of supervisors was reduced until, at the present time, the work force is comparable to that of any normal chemical plant.

Experience has shown that it is wise to start up a new reactor facility with considerable additional coverage by supervisors and engineers. At Hanford, in spite of the number of new reactors that have been started up, each one has been different enough from its predecessor to create new problems and to require the development of new operating concepts. It is well to have competent, technically trained supervisors and engineers in sufficient numbers to cover all possible sources of difficulty during the start-up and initial operating period of new reactor facilities.

Operating Organization. The Hanford reactors are manned by two principal operating groups. The processing group runs the reactor itself. The power group runs the water plant and steam generator plant. Each group has its own manager, who reports to the same area manager who is responsible for all operations and facilities within one geographical area. The processing operation concerns itself with all phases of reactor operation and management. This is where most of the unique problems peculiar to the business originate. The power group is essentially a service group supplying

Revised text of a conference paper presented at the AIEE Pacific General Meeting, Pasco, Wash., Aug. 28-30, 1957, at a session sponsored by the AIEE Committee on Nucleonics.

D. S. Lewis is with the General Electric Company, Richland, Wash.

water and emergency steam as needed for running the reactor. Power operation is more or less routine, and involves the operation of standard types of equipment without any radiation hazards. It does, however, have the very great responsibility for always having cooling water, in the required quantities, available for the reactor when needed.

Each reactor operating group is headed by a manager who has reporting to him an analyst, a relief supervisor, and four operating supervisors. All of these men are technically trained and have at least five years of direct reactor experience behind them. These jobs are held in high regard because the supervisor on duty at night is in complete charge of the operation and must make rapid appraisal of changing conditions with good judgment, and make very quick decisions concerning the operation of the reactor.

The number of men in a shift crew varies from reactor to reactor, depending on the type of work load involved. The chief operator is the highest-paid operating man on the crew, and is a very highly trained and experienced specialist. He is the individual directly charged with operating the reactor, and is normally stationed in the reactor control room. Experienced and skilled pile operators are also assigned to each crew. They perform all of the operational functions of the reactor under the guidance of a chief operator or a supervisor. The crew is rounded out by one or more utility operators, who are in the development and training stage and will be expected to qualify eventually for promotion to pile operator. All operating personnel should be high school graduates, and each starts at the beginning rate for a utility operator. It takes nearly four years to progress to the top of the utility operator grade, and experience will show that at least this amount of time is necessary before an operator is considered fully qualified in all phases of reactor work.

The original reactor operators did not know any details of the process or how their jobs fitted into the operation because of rigid wartime security requirements. This made their jobs rather innocuous and nothing much more than labor. It was not until after the war, when the men could be given more information, that they were able to be trained and developed to their present skills. Training has proved to be a never-ending process, not only for the operators, but for the management and engineering personnel as well. Because of the rapid development of the atomic energy business, new knowledge and techniques are continually requiring procedure revisions and changes in the approach to problems. It is necessary for people who have never worked around radiation to develop a good understanding of it, and to appreciate many of the required rules and regulations. Operators must be able to work a great deal of the time by themselves and without close supervision. Thus, it is necessary to have good, competent, and well-trained operator help.

Service Organizations. An even larger number of people are required to perform the servicing functions needed in support of the reactor operation. All classes of maintenance mechanics are needed. Instrument technicians and specialists are vitally important, especially on the newer reactors which have highly complex instrumentation and electronic circuits. The trend is toward automation, and greater complexity increases the requirements for experts in the instrument, electronic, and electrical fields. The other mechanical skills are also required for maintenance of the reactors.

The nature of work at an atomic energy installation requires a large number of people engaged in activities not found in other industries. Each plant has a radiation monitoring organization which is primarily concerned with radiation protection. Areas must be surveyed for radiation beams and contamination. One radiation group conducts regional surveys and monitoring of surrounding territory, and maintains exposure records. Another group in the radiation monitoring organization continually works on developing even more effective radiation detection and control methods. This group is primarily concerned with instrument development.

Process Engineering. The reactor plants are backed up by rather large process engineering staffs. Each reactor has a full-time physicist assigned to follow closely the continually changing physics aspects of the operation. Each reactor has a full-time engineer assigned to follow all operational engineering problems. There is a standards and processing group which serves all of the reactor plants and supplies up-to-date standards and procedures for operation. Because of the rapid development of the business, these people are continually revising, streamlining, and simplifying the standards of operation for the operating groups.

Shutdown Crews. The replacement of fuel elements requires the reactor to shut down periodically. During these shutdown periods, a considerable amount of reactor maintenance work is accomplished. The reactor operating periods are relatively quiet and uneventful, whereas the reactor shutdown periods are very busy. As a consequence, the number of people needed during a reactor shutdown is much greater than the number needed during reactor operation. With several reactors on the plant, it has been practical to use the services of a central crew of operators and maintenance mechanics who move from one shut-down reactor to another on schedule to assist the operating crews during reactor outages. This helps smooth out the variable manpower requirements between the reactor when it is operating and when it is shut down.

OPERATING PROCEDURES

ALTHOUGH THE HANFORD REACTORS must operate to make product, they must also shut down to discharge "ripe" fuel elements from which the plutonium is extracted. Therefore, the reactor should run on a scheduled basis to operate must efficiently. Hanford reactors are scheduled in advance to shut down in order that fuel elements may be replaced and needed maintenance

work done. As the result of equipment breakdowns and general infirmities with the older reactors, an appreciable number of unscheduled outages occur. Some of these outages are of short duration. The reactor will "scram" for some reason, such as an instrument or minor component failure, and the trouble can be immediately corrected and the reactor started up again. If the reactor does not start up again within a short period of time, a prolonged outage is required. This outage results from a build up of poisonous fission products which keep the reactor subcritical until they decay away sufficiently to allow the reactor to start up again. Because of these fission product decay problems, the reactors cannot be shut down and started up at will.

Whenever an outage occurs, whether scheduled or unscheduled, the primary concern of the operating group is to make full and efficient use of the time the reactor is shut down. If this can be done for all nonscheduled outages, and not too many of them occur, the number of scheduled outages can be reduced or even eliminated so that, over a long period of time, the desired "time operated" efficiency of the reactor can be achieved.

Some of the unscheduled outages are caused by equipment failures. Other outages result from operating failures or errors, such as varying process water pressures or flows by adding or removing pumps from the system. During changes in process flows, flow disturbances can be created which are of sufficient magnitude to cause a scram. Many delicate and exacting instrument adjustments must be made during reactor operation on some components which cannot, for nuclear safety reasons, be removed from service. In order to do this work, several people must follow exact procedures. Sometimes these adjustments must be made in a hurry; one slip or a misunderstood instruction can result in a scram. During some of this work even the indiscreet dropping of a wrench or screw driver in the wrong place at the wrong time can cause a scram. Naturally, each individual employee is responsible for observing and following operating procedures. But so-called personnel failures do not result from incompetence, lack of training, or lack of understanding of the job. They are more likely the result of the large number of adjustments and manipulations that have to be performed routinely. Experience shows that on manual work of this nature, even an experienced mechanic or operator may have a "scram" or two on his record. Most of the types of scrams just described do not prevent immediate resumption of operations. However, a detailed and conservative procedure for starting up a reactor under hot conditions must be followed. Unless certain operating conditions are met, a scram recovery is not always immediately possible, and can result in a 12- to 24-hour unscheduled outage.

Shutdown Scheduling and Planning. Hanford reactor experience, with suddenly changing conditions from operation to shutdown, has lead to the development of elaborate plans and preparations in anticipation of unscheduled outages so that no matter when an outage occurs, the time can be utilized efficiently. The two principal accomplishments during shutdowns are fuel element replacement and maintenance work. Fuel element replacement, called charge–discharge operations, requires a list of fuel columns that are ready for replacement to be supplied in advance so that the amount of fuel required can be delivered to the reactor from the fuel preparations plant, and be inspected and arranged suitably for charging, before the reactor shuts down. This sequence of events must begin well in advance of a reactor shutdown so that the charging work can begin immediately after the shutdown takes place. Another complication is that the exact time of the shutdown is required in order to determine which of the fuel columns can be discharged. Outages for charge–discharge work are scheduled in advance for this reason.

Maintenance work which has to be done at the next outage is covered by a continuous and up-to-date punch list of jobs. Each job is assigned a priority, and sufficient information is given to enable the crew on duty at the time the outage occurs to determine which jobs can be done with the manpower and materials available. In some cases, elaborate preparations, including necessary equipment, tools, and detailed written procedures, are made so that all the necessary information is available for the crew on duty when the outage occurs. The importance of having competent planning and scheduling groups cannot be emphasized too strongly.

Process Standards. The Hanford reactors release large quantities of nuclear energy. Initially, very little was known about this field, and thus the first reactors were located in a remote geographical area. As new knowledge has been acquired, new and improved safety features have been developed. In addition, the advancement of carefully considered operating procedures and controls has contributed to over-all safe working conditions. The engineering operation maintains a detailed and comprehensive set of standards for reactor operation and maintenance. These standards restrict and control virtually every detail of reactor and water plant operation and many of the maintenance procedures used. To incorporate the latest thinking, the standards are continually under study and revision. This work alone requires seven full-time engineers for the entire plant. Routine audits of the application of these standards at all reactors are made on a continuing basis around the clock to make sure that no standards violations exist. These standards form the basis for detailed written operating procedures compiled by the operating organizations of the individual reactor plants who set forth the step-wise procedures for actually performing the various operations. Although practically every course of action is covered by a written procedure, it is necessary for all key operating personnel to have immediately available considerable detail and knowledge of the standards and restrictions to enable them to decide, often very quickly, which of the many overlapping regulations and restrictions applies to the problem at

hand. Many of these restrictions apply during shutdown periods as well as during operating periods. Fission product decay in the fuel elements continues to liberate heat, and requires a continuous uninterrupted supply of cooling water to the reactor during outages.

Reactor Start-Up. The start-up of a Hanford reactor after a prolonged outage is a detailed and time-consuming job which requires considerable inspection and checking at various stages during the start-up period. A detailed written procedure is followed, and a check list of many items must be completed before actual operation can begin. Individual operators are assigned to check specific conditions and sign out the check sheets as they complete their inspections. Completed check sheets must be reviewed and approved by the supervisor in charge. Even after the reactor becomes critical, and at various stages during its rise to power, many additional checks are made both of reactor behavior itself, as well as the condition of the reactor building and area. It is important to keep track of numerous details, such as openings which are made during the outage, so that they can be disposed of properly before start-up. Any unshielded hole will be picked up on a radiation survey. The group that opens up a hole might differ from a group that closes it, and a third group might make the final check-up and start-up. Therefore, close co-ordination and communication between crews is required at all times.

Reactor Control. At Hanford, reactor control is based on the "fail-safe" principle, which means that equipment failures of critical systems cause the reactor to shut down. In order to control the reactors against excessive power levels or rapid power level increases, practically every measurable variable that is proportional to power level is included in the reactor safety circuits. Many of the variables, such as reactor internal radiation levels, are provided in duplicate, quadruplicate, or even greater numbers to insure that reactors will shut down before dangerous conditions develop. Many of these systems require calibration and adjustment during operation. In order to have as much flexibility as possible to make repairs and adjustments during operation, many of the systems are equipped with "by-pass" switches which effectively remove the system or component from the safety circuit. In order to prevent the removal of a number of these components from the safety circuit, the by-pass switches are electrically inter-locked so that only certain ones may be actuated during operation. If more than the prescribed number of by-pass switches are closed, the reactor will scram. Interlocks are also provided between certain important instruments and the reactor controls to prevent a start-up unless the instruments show that the proper operating conditions prevail.

Radiation Problems. The presence of radiation naturally complicates reactor operation. When the reactor is operating, a considerable portion of the reactor building is under restricted access. Some areas cannot be entered during the operation, and other areas can be entered only on a controlled basis. When the reactor is shut down, all of the restricted areas can be entered, usually on a controlled basis, and it is here that considerable shutdown work is accomplished. Work in these restricted areas generally involves exposure to a higher degree of radiation than usual. Special clothing must be worn to keep the individuals from becoming contaminated themselves, and oftentimes special respiratory apparatus must be worn to prevent the inhalation of radioactive particles.

Procedures have been developed throughout the years to protect personnel working in contaminated areas. Many years of experience and many thousands of man-hours have been spent in radiation zone work. Naturally, this type of work requires protective clothing. Usually a double layer of clothing is required as well as respiratory protection such as Army assault masks or fresh-air masks. Another safety feature is that an individual is limited as to the time he can work in a particular area by radiation exposure limits. On long, time-consuming jobs in radiation areas, a relay of men is often required to complete the job. This results in lost time changing from one person to another, and also results in loss of efficiency. Further losses are incurred because the extra men must be dressed and kept in standby readiness waiting for their turn on the job. Another obstacle is the difficulty in providing continuous and close supervisory follow-up. Radiation control measures make it difficult for supervisors to follow up jobs on the spot. They must sometimes rely on verbal reports which makes it difficult for them to clear up problems and unexpected conditions that develop during the course of the work.

Radiation conditions are often unpredictable, and one cannot be assured of doing a job the second time under the same radiation conditions he encountered the first time. This fact, coupled with the necessity for making every minute of shutdown time count, and further complicated by the bad habit of reactors to shut down once in a while unscheduled, often requires large numbers of mechanics for a particular job which has to be done. Because each person is limited in the amount of radiation exposure he may receive, the maintenance and operating organizations have developed procedures for funneling large numbers of people to trouble areas rapidly any hour of the day or night. Instances of this kind result in a lot of overtime work which is costly and must be considered in light of the cost of down time before a decision is made.

Radiation creates some unique problems during reactor shutdowns which require careful planning and scheduling to avoid interferences between seemingly unrelated jobs. Some jobs create quantities of radioactive dust or other light particles which become airborne and travel through the building exhaust–ventilation system. The ventilation system is designed to remove air through potentially higher contaminated areas until it eventually exhausts through the exhaust air stack under conditions that control the potential hazard. Airborne

contamination from one of the lesser areas would naturally alter the radiation exposure rates in the more contaminated areas as it passes through. This requires scheduling of jobs in different areas so that people working in more contaminated areas are not subjected to higher radiation exposures than necessary. Sometimes highly radioactive materials, or equipment of considerable size, must be removed from the reactor.

Cleaning up contaminated areas to minimize unnecessary exposure to radiation is a routine task of the operating crews. Some areas, which are impractical to keep contamination free, are set up as permanent radiation zones. Other areas become contaminated during a job, but can be decontaminated and released from controlled status at the conclusion of the work. The practicability of cleaning up and releasing an area depends to a great degree on the type of surface to be cleaned. Porous concrete, wood, and metal gratings are almost impossible to clean once they become contaminated. Whenever clean areas of this type are subject to contamination every practical precaution is taken to keep the permanent surfaces from becoming dirty. This is done by papering the floor surfaces in other areas and covering equipment with masking tape so that, when the work is completed, the contaminated tape and paper are removed and the area is returned to a clean status. It has often been found feasible to seal concrete floors with special paint which gives a hard, nonporous, and easily scrubbed surface. The use of proper structural materials in a new plant can also assist in maintaining the desired degree of cleanliness.

MAINTENANCE

MAINTENANCE is so vital to reactors that it is almost a routine part of the operation. This is because maintenance work is done during shutdowns when efficient utilization of time is so important. Many of the conditions which concern maintenance of the reactors have been mentioned previously in other sections, but some of them will be covered again to give a better picture of the over-all maintenance problems.

Reactor maintenance must be planned very thoroughly. Planning is done in advance whenever possible, and includes writing detailed procedures, fabricating special tools, training individuals, and holding "dress rehearsals" whenever possible. This type of procedure is especially necessary when large and extremely radioactive equipment is involved. Highly radioactive materials must be handled very carefully and in a deliberate manner, so that the "point of no return" is not reached which would jeopardize completion of the job because personnel could not get near enough to the work. Whenever work is attempted for the first time, procedures are usually made up very conservatively in such a fashion that, if one step does not work, it is possible to back up slightly and try another step.

It is desirable to develop the entire procedure in this fashion, and not to reach the point of no return until it is absolutely unavoidable. Many details have to be considered and thought out in advance so that when the radioactive material is brought out of the reactor all foreseeable problems have been taken into account. Distance, rigging, and shielding are used to a great extent on many jobs. Shielding is undesirable because of its bulk and handling difficulties. Distance between personnel and the material being moved is very desirable, but not always possible because of interference from the building structure. Quite a bit of rigging, ropes, pulleys, and the like are used to give good control of the job and enable the personnel to take advantage of distance.

Unfortunately, some work must be done under emergency conditions where detailed plans have not been worked out, and there is not enough time available to plan. On these occasions work efficiency is sacrificed for safety, and an even more conservative approach is taken.

The presence of contamination makes it necessary for personnel to wear protective clothing. This clothing reduces the efficiency of the worker, and also makes it difficult for all the people concerned with the job to communicate effectively with one another. In addition, many jobs, especially those that require the use of distance, take in rather wide areas. Some sections of these areas are contaminated, whereas others are "clean." Movement in and out of contaminated areas in the course of the job, therefore, is hampered because in going from a contaminated area to a clean area, the worker must remove all protective clothing.

The Hanford radiation exposure limits are generally lower than those established by the National Committee on Radiation Protection. Thus, men doing a job in areas of comparatively high radiation can work only a relatively short time on that particular assignment. To keep the job going, continual replacements in manpower are required. In order that the time lost in changing men is minimized, It is necessary that replacements be dressed in their protective gear and waiting to go on when the men they are replacing have reached their exposure time limits. This results in a very low efficiency in the use of manpower but primary concern, of course, is the safety and health of all employees. A comparatively high radiation level also limits full foreman coverage close to the job where it can be observed and guided. This requires the foreman to rely on the reports of his men, and on their doing the job without his presence. This further complicates the problem of good communications, and makes the time required to do the work longer than if there were no radiation present. Much of the work goes on over several hours, and often extends from one shift to another. Shift changes always result in lost time and, in spite of many developments to smooth the change from one shift to another, there is an inevitable slowing up of the job. Attempts are usually made to have crews overlap for a certain period, and to relieve on the job. This seems to work well on jobs that everybody knows well and are done routinely, but cannot be expected to work too well on coverage and control of the work because each crew knows intimately only that part of the job with which it is concerned.

NEW DESIGNS AND IMPROVEMENTS

THE REACTOR BUSINESS is developing so rapidly that before a new reactor can be put into operation many of its features are obsolete. The operating groups are continually "wishing" they had some improvement or other, and vow to have it included in the design of the next reactor. When the next reactor is built most of these desires that are practical are included. However, by that time the operating group has developed another list of "wishes" as long as the original list. In some instances, reactor components can be modified so that the older reactors can take advantage of new developments. This is usually possible with instrumentation and electrical systems, but the basic reactor design must remain essentially unchanged once the reactor has been constructed. It is well for the designer to look as far ahead as he can so that as much flexibility as is economical and practical can be designed into a new facility.

Radiation requires the designer to consider very carefully the materials he uses for various reactor components. Because of the difficulties with reactor maintenance discussed previously, those components which are vital to operation of the reactor or are subject to irradiation must be thoroughly evaluated before being accepted. In this age of plastics and synthetics, many of these new materials have all the desirable properties except one—they are very vulnerable to radiation damage. It is, therefore, necessary to test the reliability of components thoroughly under actual conditions before including them in the new design.

One of the biggest desires of the operating people is to design the reactors for simplified maintenance. Initially, components should be designed for long, continuous, and reliable service without any maintenance. Repair work in radiation fields should be simplified as much as possible by employing quick disconnects, easily replaced components, and similar aids to reduce the exposure time required to do the work. Simplifying the mechanical motions required is also desirable when considering the handicaps imposed on maintenance personnel by the protective clothing requirements. It is essential that reliable components be used in those systems on which operation of the reactor depends, such as the electrical circuits which operate reactor controls. Experience has shown it to be economical to use the highest quality switchgear, relays, and similar hardware in these systems to avoid reactor shutdown due to failure of one of these components.

It is hoped that new designs will continue to incorporate remote or automatic operation insofar as possible. As in the past, everything practical will be done in the design to enable the operating functions to be carried out without any significant radiation exposure to personnel. This has a twofold advantage. It enables routine operation to be done with fewer people, and it also "saves" radiation exposure for those instances when it must be used. If these design requirements are to be met, they must be considered even in the basic architectural design of the building. Many operating problems, especially with contamination control, can be avoided if potentially contaminated surfaces and areas are designed for easy cleaning.

Standard metal stairways with open grid treads and large numbers of nooks and ledges create contamination control problems. Open gratings overhead are avoided because they allow contamination to spread downward and increase the area of control necessary to confine contamination. Where possible, smooth nonporous surfaces should be employed.

For radiation protection, reactor buildings are compartmented into several shielded areas. This makes access to various parts of the building difficult, and creates a problem of communication on jobs that require crews located in separated work areas. Therefore, much reactor work depends upon good lines of communications. Equipment of the highest quality and integrity should be employed because of high background noise levels and the necesssity for personnel to speak through assault masks and other respiratory equipment. Because many jobs require mobility of people and also continually changing individuals, permanently installed microphones for transmitting and loud-speakers for receiving are utilized rather than individual telephone headsets. All components, such as microphones and speakers, are easily replaced with spares if failures occur, and the amplifiers are located in easily accessible noncontaminated areas for rapid maintenance and adjustments. Closed-circuit television offers many advantages for following the progress of work remotely and should be used widely in future reactors.

CONCLUSION

RADIATION AND EXPOSURE TIME LIMITS are two things which play an important role in the operation of a reactor. However, at Hanford, we have had long experience with them, and the working conditions are exceptionally safe and healthy. We have won several national safety awards in the past few years. Also, we should note that the typical Hanford employee does not do radiation zone work; that only a small percentage of the total plant force ever encounters radiation zone procedures. We place constant emphasis on safety and safe working conditions, and stress to each individual employee the importance of his personal attention to these factors. According to statistics, these employees are several times safer on the job than they are at home.

Radiation and time are the two factors which have the greatest influence on the operation of a nuclear reactor. They enter into almost every operating problem and convert what would normally be a straightforward operation into a very complex situation. Experience has proved that almost any problem can be handled practically through the application of creative thinking and intelligent planning. It is clear, then, that the successful operation of nuclear plants depends to an ever-increasing degree upon the quality of the advance planning, preparation, and programming performed by operating and engineering management.

Magnetic Amplifier Step Regulator

BRYAN WEBB, JR.
ASSOCIATE MEMBER AIEE

G. D. THROOP
MEMBER AIEE

PROPER VOLTAGE regulation is now becoming an increasingly important factor in efficient operation of electric power distribution systems. The degree to which a voltage regulator performs its function on these systems depends upon the accuracy and reliability of its controls. Because of fluctuating voltage conditions on most systems, the voltage-regulating and time-delay elements of the controls are subjected to many more operations than the regulator itself. A new control system has been developed employing the unique features of bistable magnetic amplifiers to perform the functions of the voltage regulating and time delay elements.

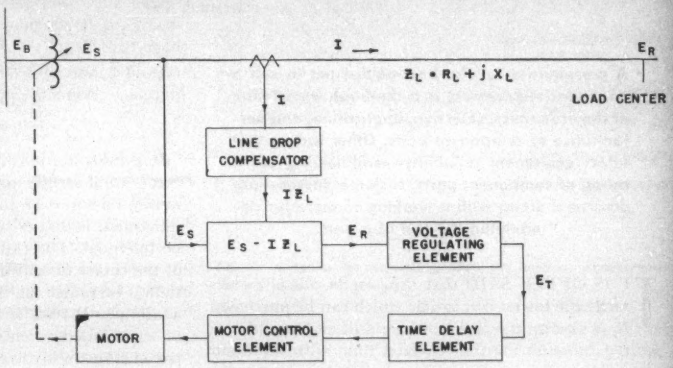


Fig. 1. Basic control system for step regulator.

Fig. 1 shows a block diagram of a step regulator control which holds the load center voltage E_R within predetermined limits. Any departure of E_R from the set limits will result in an error signal from the voltage regulating element to a time delay element. If the error exists for longer than the set time of the time delay element, the tap changer motor is energized and operates the tap changer to correct the voltage.

The static voltage regulating element consists of two basic parts: (1) a voltage detector which detects any deviation in voltage from the required balance voltage and (2) a voltage regulating magnetic amplifier which amplifies the error signal from the detector and, in turn, energizes the time delay element, a static timing circuit employing an *RC* delay circuit and a magnetic amplifier.

The voltage detector consists of two nonlinear circuits electrically matched, their outputs being equal at balance voltage but unequal at voltages above or below balance. Two bistable magnetic amplifiers are used with their control windings in series opposition. The control characteristics of the amplifiers are shown in Fig. 2 where the input is the error signal from the voltage detector.

In the characteristics shown in Fig. 2, a signal equal to *ob* is required to cause an output for the "lower" unit. This would correspond to the upper limit to which the system voltage is allowed to depart. The amplifier will maintain its output until the signal is reduced to a value less than *oa*; therefore, the distance *ab* would correspond to the compounding of electromechanical relays. Similar operation would take place in the "raise" unit.

The outputs of the voltage regulating amplifiers are matched to provide a reversible polarity voltage signal

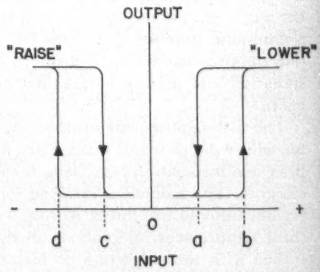


Fig. 2. Characteristics of bistable magnetic amplifier used in voltage regulating and time delay elements.

to apply to an *RC* timing circuit. To obtain delays ranging up to 90 seconds, a capacitor is charged slowly through a very large resistance and discharged through a small neon tube to give a pulse signal to bistable magnetic amplifiers having characteristics like those shown in Fig. 2. A holding signal applied by the output from the voltage regulating amplifiers has a value between *oa* and *ob* (or *oc* and *od*) and the pulse signal from the timing circuit is sufficient to cause the amplifiers to reach full output. The holding signal maintains the output until the system voltage has been corrected. The output of the time delay amplifiers energizes relays to operate the tap changer motor contactor.

Digest of paper, 57-755 "Magnetic Amplifier Control for Load Tap Changing Equipment," recommended by the AIEE Transformers Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1957.

Bryan Webb, Jr., is with the University of Arkansas, Fayetteville, Ark., and G. D. Throop is with Westinghouse Electric Corporation, Sharon, Pa.

The Economics of Component Parts Selection

E. F. FUEGEL
MEMBER AIEE

A prerequisite for the best equipment to suit a particular requirement is a thorough knowledge of the economics, selection, application, and performance of component parts. Other factors that affect equipment reliability—engineering costs, rating of component parts, customer losses—are discussed along with a working formula for determining the cost of a part.

IT IS OFTEN SAID that the best buy is not necessarily the lowest cost article which can be purchased. It is usually the article which will perform the required function for the required time with minimum over-all cost. Equipment may be designed to meet one or intermediate grades of the following requirements: (1) lowest manufacturing cost (where maintenance costs are unimportant); (2) minimum total cost (consisting of manufacturing, installation, and maintenance costs for the required time the equipment is to be used); and (3) a minimum number of failures for the required time. (No compromises are to be made in manufacturing, installation and preventive maintenance to achieve this goal.)

The first requirement involves the selection of parts for which the principle criteria are minimum purchase price and installation cost. Items such as toys are in this category. The economics involved for this requirement are obvious and will not be discussed in this paper. The third requirement, in general, involves customers concerned with the protection or maintenance of human life, where the best available components are selected and economics are trivial.

Most industrial equipment or systems must meet requirement (2) or be intermediate between (2) and (3). By contrast, entertainment and domestic equipment generally is in the range of requirements (1) and (2). Because a good share of the total electronics business falls in this category, a large number of component parts —tubes, transistors, resistors, capacitors, and transformers—are designed specifically for requirements (1) and (2).

When such components are applied to systems that must meet requirements (2) and (3), as in the case of many business machines, the result is often unsatisfactory performance. To design a satisfactory system—one that meets the necessary levels of reliability—the engineering team must possess numerous abilities, including a thorough knowledge of the requirements, environmental conditions, design techniques, and component parts selection and application.

E. F. Fuegel is with the International Business Machines Corporation, Poughkeepsie, N. Y.

RELIABILITY

BUSINESS MACHINES, like many types of electronic equipment, are designed to provide the maximum output for minimum cost over a long period of time. A further requirement is that erroneous output information cannot be tolerated. The equipment should cease to function, or the choice to continue or stop processing information should be under the control of the programmer, or the equipment should be self correcting, with an indication of what failed when maintenance is required. Where pay checks are involved, for example, the cost of errors can become intolerable.

The reliability of the system must be high. Reliability is defined as the probability that a system, when operated as intended, will provide the desired performance for the desired period of time. If a component part is used in significant quantities, the probability that a certain percentage of these parts will be within certain limits under known operating conditions can be determined, when the rating, parameter limits, environmental conditions, and time are defined.

For the purposes of this discussion, the following definitions are assumed:

Component Part. This is a basic unit, such as tube, transistor, resistor, or capacitor.

Component. This refers to a grouping of a number of componet parts into a circuit; for example, an oscillator, register, or counter.

Equipment. It consists of a number of components, usually housed in a cabinet, making up units like a card punch, sorter, tape storage unit, or memory. An equipment may be a complete entity (card punch, for example) or it may combine with other equipments to form a larger system.

System. A system is a complete operating unit, such as a digital computer, generally made up of a combination of equipments.

DUPLICATE SYSTEMS

THE USER OF A SYSTEM or equipment might define reliability as "the probability that the system or equipment will do satisfactorily what it is expected to do when I want it done." One way the customer can obtain greater reliability is to buy two machines. Then if one does not work, he can probably use the other one. The odds of getting the job done with two machines are better than with a single one. Whether the second machine

can be called redundant depends on two factors: the reliability of the first machine, and the reliability that the customer requires. If machine reliability is 95% and the customer is satisfied with 75%, the second machine is redundant. If the best machine available works only 50% of the time, then the customer must have two to meet his requirements. Duplicating entire machines is an extreme measure. The cost generally is prohibitive unless the second machine can be used for supplementary operations that do not have to be performed at specific times.

DUPLICATE COMPONENTS

ANOTHER POSSIBLE WAY to improve reliability is to duplicate unreliable components. This is possible only when the additional circuitry and parts required do not lower the over-all reliability of the system. In general, duplicating selected components rather than entire systems is preferable from a standpoint of cost, size, and weight. The duplication procedure may be expanded to three or more parallel sets of components, as required to obtain the necessary reliability.

The over-all reliability gained by duplicating components may be greater than that obtained from duplicate systems. The use of duplicate systems vs duplicate components may be considered analogous to two chains holding a load; if one link breaks, *any* link in the second chain must be able to hold the load. If a single chain is made with the same links so that two links are in parallel throughout the length of the chain, the failure of one link will mean that *only one* single link will be required to hold the load. Intuitively, it can be reasoned that the second chain is more reliable than the pair of chains.

The use of duplicate rather than single components is generally not advantageous from the viewpoints of cost, size, and weight. It should only be resorted to after all the other ways of obtaining the necessary reliability have been thoroughly explored. These include improved manufacturing and quality control methods, better design, better application of component parts, the use of duplicate component parts, and the use of marginal checking.

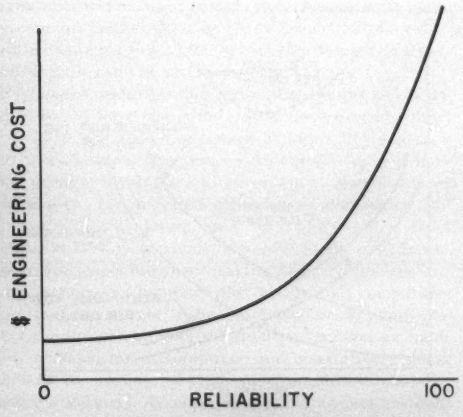


Fig. 1. Engineering costs increase as the desired reliability increases.

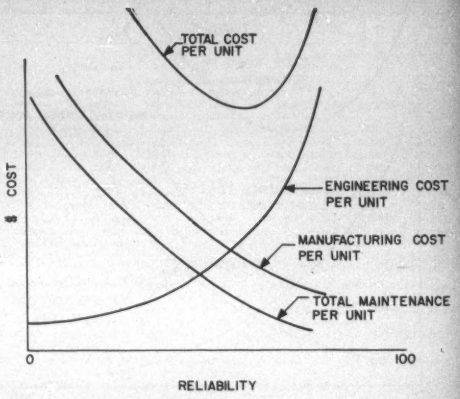


Fig. 2. Increasing the engineering effort can improve reliability and decrease manufacturing costs.

MARGINAL CHECKING

THIS IS A METHOD for detecting progressive degradation before actual equipment failures occur. It can be done as part of a preventive maintenance procedure to improve system reliability from the customer's point of view. However, this type of checking does not spot potential catastrophic failures. Also, rapid marginal checking of the component parts in equipment may require additional circuitry that will increase the total size, weight, and cost. The additional cost of such equipment, the cost of maintenance and periodic testing, the reliability obtained, and the availability of the equipment to the maintenance man are factors that must be considered carefully before advocating a marginal checking system.

RATING OF COMPONENT PARTS

IT IS WELL KNOWN that many good component parts are available. A large percentage of equipment failures are caused by poor selection, control, and application of component parts. To design reliable equipment, the circuit designer must apply them in a way that provides the best performance.

Using the manufacturer's rating or arbitrarily altering it to 1/2 or twice the rating will not necessarily provide the desired results. The probable life of a component part depends on how it is applied. The manufacturer's rating is often arbitrary and is usually not the best rating for the equipment which is being designed. Frequently it is possible to select less expensive component parts and obtain the desired reliability by derating.

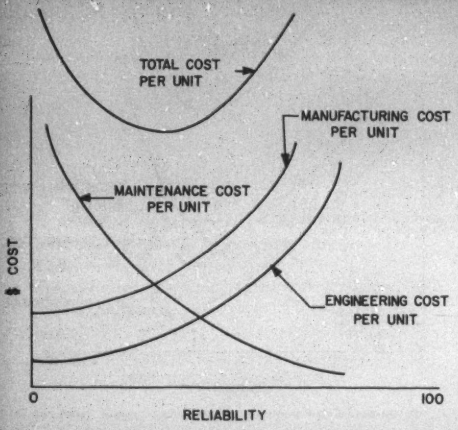


Fig. 3. Higher manufacturing costs are sometimes necessary to obtain the desired reliability.

The tolerance on the purchased component part is the manufacturing tolerance. It in no way indicates how much larger the tolerance will be after the part has been in service for the desired time. It is this larger tolerance that is applicable, and it will be referred to here as the design tolerance.

The rating and the design tolerances of component parts which can be manufactured within reproducible limits should be based on the period of time during which the equipment is expected to operate. The rating and design tolerance which is determined by life testing are based on the probability of a certain percentage of component parts remaining within the design tolerance for the required time. The basis for the rating, design tolerance and survival percentage includes the availability and the cost of the parts.

The life testing of component parts to obtain the probable survival percentages for intermediate times is expensive but necessary. Manufacturers of component parts generally do not have data available for each type of equipment requirement because of the immense variety of requirements and the expense of obtaining the data. Many manufacturers test their own and competitors' products only to determine whether they have improved their product, and to see what their competitive position is.

WHY LIFE TEST COMPONENT PARTS?

THE ADVANTAGES OF LIFE TESTING component parts are as follows:

1. An estimate of the reliability of a component or system may be determined from the component part reliabilities before even a prototype is built. Changes can be made more readily in the design stage to obtain the desired reliability.

2. A basic group of component parts can be used in a large number of components. A number of samples must be life tested to obtain reliability data, which in the case of components or systems may be more expensive, especially if a number of changes had to be made to obtain the desired reliability.

3. The time involved in life testing components or systems is prohibitive when a life expectancy of 20,000 or 50,000 hours is desired. Utilizing standard component parts facilitates reliability and reduces the time and over-all cost. The component parts art does not change as rapidly as the requirements for new circuits. Therefore, estimates of the reliability of parts can be obtained before parts are used in circuits.

4. Improvements and cost reductions in component parts can be recognized and incorporated in existing or new components if a continued surveillance is made on component part reliability.

It is not to be inferred that evaluation of the component or system is not necessary. The component must be evaluated to determine that the component parts are applied properly, including the dependence of component parts on each other, and that the component will function as desired initially, and for the desired life expectancy.

COST CONSIDERATIONS

Engineering Costs. The cost of engineering a reliable product usually increases as the desired reliability increases. This relationship is shown in Fig. 1. It is usually more expensive to achieve a simple design than a complex one. Designing equipment that will minimize manufacturing errors takes considerably more effort than designs which do not take manufacturing difficulties into account. As reliability is increased, the costs of evaluation, testing, design, and control all increase.

Total Cost. The manufacturing cost may either increase

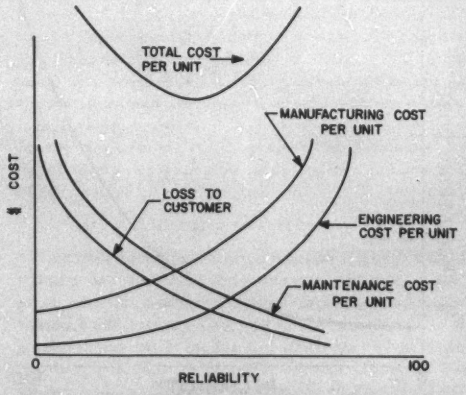


Fig. 4. The "loss to customer" cost can affect the total cost curve.

or decrease as a function of reliability, depending on the type of equipment, manufacturing methods, manufacturing difficulties, design complexity, and the selection and control of materials in the product. It is often possible to improve reliability and reduce manufacturing costs by increasing the engineering expenditure. Such a situation is illustrated in Fig. 2. With some equipment, however, the desired reliability can be obtained only by complex manufacturing procedures and controls, more expensive materials, and complex designs. In such cases, the manufacturing cost will increase as reliability increases, as shown in Fig. 3.

The sum of the manufacturing, maintenance, and engineering costs over the desired life is the criterion that determines the optimum allocation of expenditures. Thus, in Figs. 2 and 3 the total cost per unit curve is the most significant one, and the lowest point on it is the ideal operating point, economically speaking. However, in most cases customer demands for high

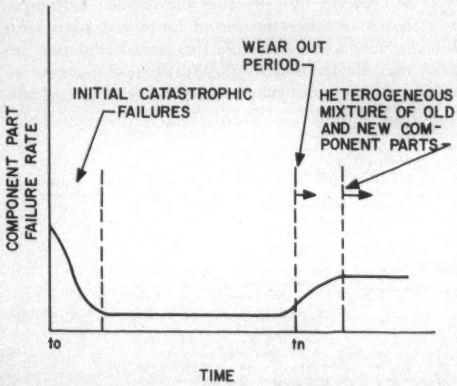


Fig. 5. A typical curve for the failure rate of component parts vs time.

reliability must be considered, and a compromise made on the optimum operating point. From the plant controller's point of view, the figures can be used in determining the ratio of income to expenditures.

Customer Losses. Another factor that should be considered in the total cost is the loss to the customer caused by equipment failure, as shown in Fig. 4. If other costs remain the same, the "loss to customer" cost will have the effect of shifting the total cost curve towards higher reliability. The required reliability is that which will provide the maximum profit to the customer. Optimum reliability is usually determined by past experience and good judgment, taking into account the factors previously discussed plus things like competitive position, time, state of the art, taxes, interest, and market conditions. As more information becomes available by increased use of computers and accounting systems, it will be possible to determine optimum reliability more accurately. It may be possible to use methods involving successive approximations.

Table I.

Component Part	Purchase Cost of Part (P)	Labor Cost to Replace (in dollars) (L_0)	Number of Parts (N)	Average Failure Rate per 1,000 hours (F) for T_n 5,000	10,000	20,000	50,000
A_1	$0.80	5.00	60	0.01	0.01	0.01	0.01
A_2	1.90	3.00	60	0.005	0.005	0.005	0.005
A_3	3.50	3.00	60	0.001	0.001	0.001	0.001
B_1	0.03	8.50	360	0.0005	0.001	0.002	0.005
B_2	0.15	5.00	360	0.001	0.0006	0.0008	0.001
B_3	0.50	5.00	360	0.0001	0.0001	0.0002	0.0003
C_1	0.25	4.50	250	0.001	0.002	0.003	0.004
C_2	0.75	4.50	250	0.0001	0.0001	0.00015	0.0002
D (Large number of miscellaneous parts-maintenance estimated from experience on previous equipments)							

CONDITIONS

1. If quantity of part B is increased by 20%, failure rates of A decrease by 10%.
2. If design tolerance of B is reduced by 3% failure rates increase: B_1 by 25%, B_2 10%, B_3 5%. However, quantity of part A is reduced 15% and the failure rates remain the same. Also, "population" of part C is reduced 15%.
3. If the voltage rating of part C is halved, the cost of all parts C is reduced 40%. However, failure rate of C increases by a factor of 8.
4. Ten percent of the part C failures will cause an equal number of additional parts A to fail.
5. Loss to the customer (L_0) each time a failure occurs is $6.00.

EXAMPLE

EXPERIENCE WITH A NUMBER of equipments indicates that the failure rate vs time characteristic for large numbers of a component part type generally takes the form shown in Fig. 5, where parts are replaced in the system immediately after a failure occurs. The plateau at the right in Fig. 5 is the result of replacing failed component parts, because these replaced parts generally have a higher probability of surviving to a specified time than those which have been in the system longer. The average failure rate is the portion of the "population" which fails during a specified time.

Tables I and II illustrate the economical selection and application of parts, using the principles previously described. Table I lists groups of typical component parts, showing numbers used, purchase and replacement costs, and failure rates. (These are average failure rates per 1,000 hours for periods of 5,000, 10,000, 20,000, and 50,000 hours. They depend on how the component parts are applied in the circuits, and on the environmental conditions. E. E. Brewer,[1] of the Convair Corporation located in Pomona, Calif., has discussed various methods of obtaining operating failure rates from component part failure rate data.) Also shown

Table II.

Component Part	Applicable Conditions	Equipment Life in Hours (T_n) 5,000	10,000	20,000	50,000
A_1	2	$ 72			
A_1	2		$ 106		
A_2	2, 3			$ 157	
A_2	2				$ 213
B_1	2	$ 27			
B_1	2		$ 76		
B_2	2			$ 125	
B_2	2				$ 245
C_1	2	$ 64			
C_1	2		$ 99		
C_2	2, 3			$ 151	
C_2	2				$ 183
D		$ 100	$ 150	$ 300	$ 1900
Total Cost		$ 263	$ 431	$ 733	$ 2541
Cost per Hour		$0.053	$0.043	$0.037	$0.051
Average No. of Failures Excluding (D)		4.9	14.2	17.1	10.6

in this table are five assumed conditions that will govern the calculations of this example.

Table II shows the costs as worked out from the data of Table I, and indicates the optimum selection of parts A, B, and C under conditions 1, 2, and 3 (conditions 4 and 5 apply to all selections). The cost of a part, neglecting factors like interest, installation cost, and inspection cost, is calculated from the following formula:

$$P(N) + (P + L_a + L_o)(N)(F)(T_n/1{,}000)$$

where

P = purchase cost of part
N = number of parts
L_a = cost of replacing failed part
L_o = loss of customer when part fails
F = average failure rate/1,000 hours
T_n = total time equipment is expected to operate

The optimum solution is readily obtained by applying this formula and simple arithmetic to the various possibilities. As shown in Table II, the optimum selection for this example is a combination of part A_2 (conditions 2 and 3), part B_2 (condition 2), and part C_2 (conditions 3 and 2), over an equipment life of 20,000 hours. This results in an average cost of $0.037 per hour.

CONCLUSIONS

To make improvements in the reliability evaluations and procedures, it is necessary to have a continuous field surveillance program correlating laboratory and design procedures with actual field equipment and component part failures. Also, a constant watch must be kept on the quality control inspection of incoming component parts, to see if the part manufacturer is providing a reproducible product within the specified limits. This is necessary because the probable tolerance limits after a specified period of time depend on the probable limits at time zero and the probable aging characteristics of the parts.

The first step in arriving at the best equipment for a particular requirement is a thorough knowledge of the economics, selection, application, and performance of component parts. Thereafter, reliability may be improved in several ways. Expending more engineering effort may make it possible to use component parts with broader design tolerances. This generally will decrease the purchase cost of the parts and improve the reliability of the equipment. Reducing the number of component parts may increase reliability and at the same time cut manufacturing costs. Higher reliability may be achieved by increasing the number of components parts to allow the use of lower cost parts with broader tolerances. Likewise, the most economical results may be realized by duplicating components or using periodic maintenance marginal testing methods.

REFERENCE

1. "Mathematical Tools for Reliable Design." E. E. Brewer. *Proceedings*, Electrical Industries Association (formerly RETMA) Symposium on Reliable Application of Electron Tubes, May 21-22, 1956.

International Activities in Insulation Temperature Classification

L. J. BERBERICH
FELLOW AIEE

K. N. MATHES
MEMBER AIEE

New synthetic materials with improved thermal stability have brought about a new approach to insulation classification by "accepted test and experience." The evolution of this new philosophy is reviewed with emphasis on its international aspects.

THE PUBLICATION of the latest edition of AIEE Standard No. 1 in June 1957, entitled "General Principles upon Which Temperature Limits Are Based in the Rating of Electrical Equipment" affords an appropriate opportunity to consider the international situation in the same area. The development of a new approach to insulation classification in the United States has influenced international developments in this area. On the other hand, activities sponsored by the International Electrotechnical Commission (IEC) have also contributed to U. S. progress. For example, the definitions of the temperature classes in the new AIEE No. 1 follow nearly word for word the new IEC Publication 85 which was circulated to the various national committees under the "six months rule" in May 1955 and issued early in 1957 under the title "Recommendations for the

A special article recommended for publication by the AIEE Co-ordinating Committee No. 4 of the AIEE Standards Committee.

L. J. Berberich is with the Westinghouse Electric Corp., East Pittsburgh, Pa., and K. N. Mathes is with the General Electric Company, Schenectady, N. Y.

Classification of Materials for Insulation of Electrical Machinery and Apparatus in Relation to Their Thermal Stability in Service." The definitions of the various insulation classes of the new IEC Publication 85 are given in the second column of Table I.

Table I. Definitions of Temperature Classes—IEC Publication 85

Class and Hottest Spot Temperature Limit	Definition
Class Y 90 C	Class Y insulation consists of materials or combinations of materials such as cotton, silk, and paper without impregnation. Other materials or combinations of materials may be included in this class if by experience or accepted tests they can be shown to be capable of operation at Class Y temperatures.
Class A 105 C	Class A insulation consists of materials or combinations of materials such as cotton, silk, and paper when suitably impregnated or coated or when immersed in a dielectric liquid such as oil. Other materials or combinations of materials may be included in this class if by experience or accepted tests they can be shown to be capable of operation at Class A temperatures.
Class E 120 C	Class E insulation consists of materials or combinations of materials which by experience or accepted tests can be shown to be capable of operation at Class E temperatures (materials possessing a degree of thermal stability allowing them to be operated at a temperature 15 centigrade degrees higher than Class A materials).
Class B 130 C	Class B insulation consists of materials or combinations of materials such as mica, glass fiber, asbestos, etc., with suitable bonding substances. Other materials or combinations of materials, not necessarily inorganic, may be included in this class, if by experience or accepted tests they can be shown to be capable of operation at Class B temperatures.
Class F 155 C	Class F insulation consists of materials or combinations of materials such as mica, glass fiber, asbestos, with suitable bonding substances as well as other materials or combinations of materials, not necessarily inorganic, which by experience or accepted tests can be shown to be capable of operation at Class F temperatures (materials possessing a degree of thermal stability allowing them to be operated at a temperature 25 centigrade degrees higher than Class B materials).
Class H 180 C	Class H insulation consists of materials such as silicone elastomer and combinations of materials such as mica, glass fiber, asbestos, etc., with suitable bonding substances such as appropriate silicone resins. Other materials or combinations of materials may be included in this class if by experience or accepted tests they can be shown to be capable of operation at Class H temperatures.
Class C Above 180 C	Class C insulation consists of materials or combinations of materials such as mica, porcelain, glass, and quartz with or without an inorganic binder. Other materials or combinations of materials may be included in this class, if by experience or accepted tests they can be shown to be capable of operation at temperatures above the Class H limit. Specific materials or combinations of materials in this class will have a temperature limit which is dependent upon their physical, chemical, and electrical properties.

It should be observed that the definitions of the various insulation classes are no longer written around the words "organic" and "inorganic" as is the case with both the 1954 edition of AIEE No. 1 and 1935 edition of the corresponding IEC document. This change has been brought about by the advent of many new synthetic organic materials having thermal stabilities expected of Class B (130 C maximum hottest spot temperature) and even Class H (180 C) materials.

It is remarkable that the basic philosophy of insulation temperature classification introduced by C. P. Steinmetz and B. G. Lamme in 1913[1] still persists, and that only minor modifications have been made until the present time. The new editions of AIEE No. 1 and the corresponding IEC document still show traces of this older philosophy but contain important changes which point the way toward the new philosophy designed to fit the present needs of the electrical industry. They might be referred to as transition documents, since they express the change from insulation temperature classification by definition to one by test and performance. They permit, for example, the use of organic materials at Class B, or even Class H temperatures, provided it can be shown by accepted test or experience that the material will meet the requirements of these classes. AIEE No. 1 also provides some of the tools required to accomplish this result; namely, guides for the preparation of test procedures for the thermal evaluation of materials, and systems of materials as used in electrical equipment. Unfortunately, it will require time to develop these test procedures and even more time to obtain the thermal aging data upon which the new method is based. A good start, however, has been made which has given form and substance to the new philosophy. Important progress is expected in this area in the next decade. More details and the underlying principles are given in several other recent papers[2,3,4] on this subject.

Some understandable differences in the international and United States positions on the thermal classification of insulating materials have appeared during the development of these standards. It should be pointed out, however, that many of these differences have been resolved through a spirit of international compromise and co-operation that has been truly remarkable throughout the history of this important work.

HISTORICAL BACKGROUND

THE EARLIEST REFERENCE to the rating of electrical equipment in respect to thermal classification of insulating materials appears to have been made in the 1898 AIEE *Transactions*.[5] From its very beginning at St. Louis in the U.S.A. in 1904, and particularly at the Milan (Italy) Conference of 1906, the IEC has been concerned with the problem of thermal classification of insulating materials. While the first edition of IEC Publication No. 34 was published in 1920, the definitions for the early insulation temperature classes were not added until the 1927 proof, and these first appeared in the 1930 edition. AIEE No. 1 was also being developed at that time and first appeared as a separate formal document in 1925. The definitions of the early temperature classes, however, were already established on a firm basis since they formed part of the AIEE Standardization Rules published in 1915. Much of the early stimulus for the advance in this area can be attributed to Steinmetz and Lamme whose classic work led first to the AIEE Standardization Rules, and later to AIEE No. 1. To trace the history of insulation temperature classification, one needs only to review the bibliography given in Appendix II of the 1957 edition of AIEE No. 1. Although this bibliography emphasizes papers by American authors, important contributions were also made by Brit-

ish, German, French, Swedish, Swiss, Japanese, and other authors, thus demonstrating the true international character of this important field of standardization.

During the first part of this century most industrialized countries developed their own standards for the thermal classification of insulating materials. A table of definitions appears in the British Standards at least as early as 1917. The definitions and temperature limits used in the different countries including the United States varied considerably and evolved slowly as agreement was reached in the IEC from the 1930 edition of IEC Publication 34 to the 1957 edition of IEC Publication 85.

The beginnings of the new philosophy of insulation classification may be said to date back to the 1930's when Montsinger[6] and others tried to relate the effects of time and temperature to the properties, or more particularly to the life of insulating materials. This soon led to the well-known "8-degree rule" for oil-impregnated transformer insulation, which states that the rate of deterioration is doubled for every 8-degree centigrade rise of temperature. Expressed in another manner, this means that the life of transformer insulation is halved for every 8-degree rise in temperature. This important finding, though only approximately true, was soon applied to the loading of transformers when it was recognized that a short-time overload would not destroy the transformer, but merely reduce the normal life by an amount which could be computed from the temperature and time duration of the overload.

The procedure was later extended to other apparatus although not covered by formal standards.

This rule-of-thumb relationship between life of insulation and temperature was used in varying ways until the late 1940's. It was then found, as the chemist had long since known, that the chemical reaction rate theory as exemplified by the classic Arrhenius equation may be applied to insulation aging. If it is postulated that insulation deterioration approximates a first order chemical reaction rate, as has been shown to be true in many cases, the Arrhenius equation may be expressed as follows:

$$\text{Deterioration Rate} = Ae^{-B/T} \tag{1}$$

or, since life L is reciprocally related to the rate of deterioration, life may be expressed as

$$\text{Life} = L = A' e^{B/T} \tag{2}$$

which may be converted to the logarithmic form or

$$\text{Log } L = \text{Log } A' + B/T \tag{3}$$

where T is the absolute temperature, A, A', and B are constants determined by the activation energy of the particular reaction, the gas constant and the concentration of the reacting materials. Thus, equation 3 indicates that if the logarithm of the life of insulation is plotted against the reciprocal of the absolute temperature, a straight line should result.

This relationship was confirmed, with few exceptions, by data obtained on many materials. It was found, for example, by Friedman and one of the authors[7] that when the logarithm of the life of chlorinated diphenyl-impregnated paper capacitors is plotted against the reciprocal of the absolute temperature, almost perfect straight lines resulted. The exceptions were found when the second and higher order reaction rates enter into aging phenomenon which sometimes take place at the higher temperatures. Extensive application of reaction rate theory to insulation deterioration was not made until relatively recently. This was further stimulated by two important general papers on this subject, the first by Dakin[8] which appeared in this country in 1948 and the second by Mamlow[9] which appeared in Sweden in 1949. This again points up the international character of contributions in this field. These two papers thoroughly review the principles upon which the Arrhenius equation is based and show how they apply to the analysis of insulation deterioration data.

In the last few years, these principles have been incorporated into accelerated life tests which have formed the basis of procedures for determining the thermal rating of materials[10] and systems of materials as they are used in various types of electrical equipment.[11,12] These procedures all require the obtaining of aging data under prescribed conditions and plotting the statistically analyzed data on a log-life versus reciprocal of the absolute temperature plot. Then, if it is established that the data form approximate straight lines on this type of plot, as often is the case, the line may be extrapolated with caution to a generally accepted standard life value and the corresponding temperature rating may be read from the plot. Thus, the approximate "rule of thumb" relations having no scientific basis, have now been almost entirely replaced by the more accurate relation based on the classic Arrhenius equation. It has also been only recently realized that the temperature-rise interval over which the insulation life is halved is not a constant, but increases with the temperature for a given material, provided a single reaction rate law is obeyed over the whole temperature range.

Several years ago, it became apparent in both the United States and Europe that the temperature classes as defined in AIEE No. 1 and IEC Publication 34 no longer met the needs of the electrical industry. The rapid and continuing developments, particularly in polymer chemistry all over the world, led to extremely useful insulating materials the temperature limits of which were not adequately characterized by the definitions in the earlier insulation temperature standards. In Europe particularly, the relative importance of materials in the economy and the need to get the most out of the available materials led to the suggestion for new Classes E (120 C) and F (155 C.) In addition, it was proposed that the classical definitions might be replaced by merely listing each kind of material in the appropriate class. Such a list appears as an appendix in IEC Publication 85, but is considered to be only a general guide to the selection of materials and its use is not mandatory. This change in point of view was initiated by the United

States[2,3] but found understanding and rapid acceptance by other countries for the following reasons listed in IEC Publication 85: "(a) Many materials are available in a number of variants of differing thermal stability; (b) The thermal stability of some materials is affected by the way in which they are combined with other materials; (c) The suitability of some materials for use in a particular class depends upon the function which they will be called upon to fulfill."

As a substitute for the mere listing of materials, a performance classification "by experience or accepted test" was agreed upon in IEC Publication 85, which was subsequently also to appear in the 1957 edition of AIEE No. 1. Considerable experimental work is presently under way in Europe, in some instances following evaluation methods[6,9,10] developed in the United States. The United States has accepted a 155 C class (Class F) first suggested in Europe but has not accepted 120 C class (Class E). The need for evaluation test procedures for materials and systems of materials has been recognized in AIEE No. 1 with two addenda which are: (1) AIEE 1D, Guide for the Preparation of Test Procedures for the Thermal Evaluation of Electrical Insulating Materials; and (2) AIEE 1E, Guide for the Preparation of Procedures for the Thermal Evaluation of Insulation Systems for Electric Equipment.

These guides will be given consideration in United States proposals to the IEC at its next meeting to be held at Stockholm, Sweden, in 1958.

ACTIVITIES IN THE UNITED STATES

In order to implement the new approach to the thermal classification of materials and the rating of electric equipment, the necessary organization had to be developed. In this country, the AIEE has traditionally been concerned with the principles of rating electric equipment and the thermal classification of insulating materials used in such equipment. The American Society for Testing Materials (ASTM) has been concerned with test methods and specifications for materials. The American Standards Association (ASA) is the over-all co-ordinating and standardizing agency in the United States which approves national standards and appoints representatives and advisers to serve on the various committees of the International Electrotechnical Commission. The National Electrical Manufacturers Association develops industry standards in the electrical area and contributes to international standardization in a number of ways.

As soon as it became apparent that action should be taken to carry out the new philosophy of insulation classification in this country, appropriate subcommittees and working groups were appointed within the existing AIEE Committee structure. The work of these groups has proceeded along two major lines. This includes the development of test procedures for (1) materials and simple combinations of materials,[10] and (2) systems of materials as they are used in various types of equipment. In the materials area, the work is being carried out by the AIEE Dielectrics Committee with assistance from ASTM. In the apparatus insulation systems area, work on motor and transformer insulation systems is being carried out by the AIEE Rotating Machinery Committee and Transformers Committee, respectively.[11,12]

AIEE Co-ordinating Committee No. 4 was organized to co-ordinate the work of these various groups and to incorporate the results of this work into AIEE No. 1 through its revision. The latest revision of AIEE No. 1 provides the basic concepts for the temperature classification of materials as well as for the temperature rating of insulation systems for electric equipment in accordance with new philosophy. AIEE 1D and 1E consists of guides for the preparation of test procedures for the thermal evaluation of insulation materials as well as for insulation systems for electric equipment. The standard recognizes that the life required of various types of electrical equipment varies from 20 years or more for industrial equipment to only a few hours or even minutes for some military equipment, such as missiles. Thus, the temperature rating of a particular piece of equipment insulated with a material of a given class of insulation may vary greatly according to the life required. Thus, test procedures and the analysis of the results according to chemical rate theory provide the tools not only for classifying materials, but also for determining the temperature ratings of various types of equipment on an equivalent life basis.

The recently revised standard also suggests that reference be made to the various insulation temperature classes by the numerical value of the temperature in degrees Centigrade rather than by the letter class designations.[3] The latter, however, are still listed as an alternate which will probably disappear from later revisions as the use of the former becomes generally accepted. The recently proposed temperature classes for materials are indicated in Table II.

Table II. Temperature Classes for Insulating Materials

Temperature Class, degrees C	Alternative Nomenclature
90	Class O
105	Class A
130	Class B
155	Class F
180	Class H
220	Class —
Over 220	Class C

It will be observed by comparing Tables I and II that a new class which does not appear in the IEC Standard, namely the 220 C class, has been added to the AIEE Standard and that the 120 C Class (Class E) which appears in the IEC Standard has been omitted in the corresponding United States Government document. It will also be observed that a temperature of over 220 C has been assigned to the former Class C in the AIEE document as compared with 180 C in the IEC document. A study of the two documents will reveal other differences which might be summarized by saying the new

philosophy of insulation classification is carried a step further in the 1957 edition of AIEE No. 1.

INTERNATIONAL ACTIVITIES

IT IS BEYOND the intent and scope to discuss here the ways in which thermal classification is carried out in other countries or the interrelationship between international technical and standardizing bodies. Traditionally, the rating of electric equipment and the classification of insulating materials has been considered in IEC Technical Committee 2 on Rotating Machinery. After a lapse in activity during World War II, Subcommittee 2C was formed at the 1951 IEC meeting in Estoril, Portugal, under a United Kingdom chairman and secretariat to carry out revision of Publication 34 with co-operation from the then newly formed Technical Committee 15 on Insulating Materials. TC-2C met in March 1952 in London, England, and in September 1952 in Scheveningen, Holland. The new concept of insulation classification as it was developing in the United States was first introduced into the international area by the United States delegation at the 1953 meeting of the Commission held in Opatija, Yugoslavia. Some of the more important details of the revision were developed at a special meeting of Subcommittee 2C of Technical Committee 2 held in London, England, early in 1954. The document incorporating the revision was later finalized at the regular meeting of the Commission held in Philadelphia, Pa., in September 1954. This document was next submitted to the various national committees for final approval under the title "Recommendations for the Classification of Materials for the Insulation of Electrical Machinery and Apparatus in Relation to Their Thermal Stability in Service," and finally issued in 1957.

Recognizing the need for test methods to determine the thermal stability of insulating materials, TC-15 established Working Group No. 7 on Thermal Stability at the 1954 meeting in Philadelphia. This group was assigned the task of developing test procedures for evaluating the thermal stability of materials. The group met at Munich, Germany, during the meeting of the Commission in 1956 and consideration was given by delegates of 12 nations to the various test procedures developed in the United States. The test procedure for enameled wire issued in the United States as AIEE No. 57 is now being studied by a number of nations and it is anticipated that further progress will be made on this and other test procedures in 1958, when the group is scheduled to meet in Stockholm at the next regular meeting of the Commission. Considerable interest has been stimulated in this work and contributions from a number of countries are being made and more can be expected in the future.

Committee TC-15 on Insulating Materials will meet in Stockholm during July 1958. It has been indicated that subcommittee TC-2C will probably meet at the same time. Since considerable interest has been stimulated, appreciable activity can be expected. With the high degree of co-operation shown so far by a considerable number of interested nations, progress is inevitable in this very important field of international standardization.

SUMMARY AND CONCLUSIONS

AIEE No. 1 and the corresponding international document were revised during the 1954-57 period. The revised documents now permit the electrical industry to take better advantage of the many new synthetic materials with improved thermal stability which have become available in recent years. These revisions were stimulated by a change in philosophy of insulation temperature classification by definition in loose chemical terms to classification by test and performance. This new philosophy is carried a step further in the 1957 edition of AIEE No. 1. The insulation evaluation procedures required to implement the new philosophy are being actively developed both in this country and internationally. It is expected that insulation temperature standards will be a continued important activity in future meetings of the IEC, especially in respect to implementing the new philosophy of insulation classification by the development of test procedures. Much work on an international basis is required to carry this monumental task to its final conclusion. It appears certain that the necessary co-operation from many nations will be obtained to achieve this goal.

REFERENCES

1. Temperature and Electrical Insulation, C. P. Steinmetz, B. G. Lamme. AIEE *Transactions*, vol. 32, pt. 1, 1913, pp. 79-152.

2. Principles for Temperature Classification of Insulating Materials by Functional Test, K. N. Mathes. *Electrical Engineering*, vol. 73, Mar. 1954, pp. 243-46.

3. Guiding Principles in the Thermal Evaluation of Electrical Insulation, L. J. Berberich, T. W. Dakin. AIEE *Power Apparatus and Systems*, vol. 75, pt. III, 1956, pp. 752-61.

4. International Activities on the Thermal Evaluation of Insulating Materials, L. J. Berberich. *Electrical Engineering*, vol. 73, Mar. 1954, pp. 240-43.

5. The Standardization of Generators, Motors and Transformers, AIEE *Transactions*, vol. 15, 1898, pp. 3-32.

6. Loading Transformers by Temperature, V. M. Montsinger. AIEE *Transactions*, vol. 49, 1930, pp. 776-92.

7. Stabilization of Chlorinated Diphenyl in Paper Capacitors, L. J. Berberich, R. Friedman. *Industrial and Engineering Chemistry*, Easton, Pa., vol. 40, 1948, pp. 117-23.

8. Electrical Insulation Deterioration Treated as a Chemical Rate Phenomenon, T. W. Dakin, AIEE *Transactions*, vol. 67, 1948, pp. 113-18.

9. Thermal Aging properties of Cellulose Insulating Materials, G. Mamlöw. *Acta Polytechnica*, Royal Swedish Academy of Engineering Sciences, Stockholm, Sweden, vol. 2, No. 1, 1949, pp. 1-67.

10. Thermal Evaluation of Enameled Magnet Wire, J. F. Dexter. AIEE *Power Apparatus and Systems* vol. 75, 1956, pp. 40-44. See also AIEE No. 57, "Test Procedure for the Evaluation of the Thermal Stability of Enameled Magnet Wire," 1955.

11. New Performance Standards for Electrical Insulation of Rotating Machines, AIEE Committee Report. AIEE *Power Apparatus and Systems*, vol. 73, 1954, pp. 1542-46. See also, AIEE No. 510, "Test Procedure for Evaluation of Systems of Insulating Materials for Random-Wound Electrical Machinery," 1956, and AIEE No. 511 covering the "Test Procedure for Evaluation of Systems of Insulating Materials for Electric Machinery Employing Form-Wound Pre-Insulated Coils," 1956.

12. Proposed Test Code for Functional Temperature Endurance Tests of Ventilated Dry-Type Power and Distribution Transformers, AIEE Committee Report. AIEE *Power Apparatus and Systems*, vol. 74, 1955, pp. 971-77. See also, AIEE No. 65, "Test Procedure for the Thermal Evaluation of Ventilated Dry-Type Power and Distribution Transformers," 1956.

The Trans-Canadian Microwave System

S. BONNEVILLE

THE SUBJECT of transcontinental telephone communications in Canada was recently reviewed in an article entitled, "Development of Transcontinental Communications in Canada," by J. W. Noyes, G. Gaudet, and S. Bonneville, which appeared in AIEE *Communications and Electronics*, July 1956, and in which reference was made to the long-term relief plans of the Trans-Canada Telephone System. It was pointed out that this envisaged a coast-to-coast radio relay system carrying television and L carrier facilities. The construction of this system is now well advanced and is scheduled for completion in 1958.

It is the purpose of this article to review the features which have been adopted to meet our particular conditions. Spur route arrangements associated with the microwave system to provide telephone and television service along the route at points remote from the terminals were presented at the AIEE Summer General Meeting held recently in Montreal, Canada, in a paper entitled "Light Route Microwave Systems in Canada," By A. J. Dinnin.

In 1932, the Trans-Canada Telephone System was formed in order to provide and maintain satisfactory long distance facilities across Canada, and to establish uniform operating procedures which would speed the handling of long distance traffic. Although each administration provides the plant and equipment required to furnish service in its own territory, the construction, operation, and maintenance of the Canadian Transcontinental microwave system is being undertaken by the Trans-Canada Telephone System.

The total system mileage, including spurs, will be about 4,800 miles. There will be approximately 137 repeater points on the main route. The Buffalo–Toronto–Ottawa–Montreal section was placed in service in 1953. This was extended to Quebec City in 1954. The Toronto–Winnipeg section was placed in service for television in September 1956 and for message service in November 1956. If the present construction schedule can be maintained, the entire system will be completed in the year 1958.

In order to meet acceptable objectives for distances up to 4,000 miles and at the same time provide large blocks of telephone circuits and several television circuits, it was decided to use Northern Electric *TD-2* microwave equipment. This is a high capacity system designed by the Bell Telephone Laboratories to meet high over-all standards. This equipment operates in the common carrier 4,000 mc band.

The system has a capacity of six radio channels in each direction. Each two-way channel will handle two television programs or 600 telephone circuits. One two-way channel of the six is normally reserved for protection. Thus, a fully loaded system would have five working channels with a capacity of 3,000 telephone circuits or five two-way television channels or a combination of both. However, as each channel has an effective baseband width of approximately 10 mc, and as a television program only occupies a 4-mc bandwidth, it is possible under certain conditions to carry a television program and a moderate number of telephone circuits on the same channel simultaneously, the controlling factor being the noise appearing in the telephone circuits. This process is known as "double decking" and will be employed initially on several sections of the transcontinental system.

By using regular and slot frequencies, the *TD-2* System makes efficient use of the spectrum. Also, the *TD-2* System, by employing one protection channel for five working channels, assures a high usage of the channel capacity.

Studies made during the initial planning stages of the transcontinental system disclosed that originally there would be a requirement for the provision of transmission facilities for a television program and a limited number of telephone circuits. When one considered the great distance involved, it soon became apparent that some simplification of the existing *TD-2* System would be required if the first costs of the system were to be kept to a reasonable figure. Several possibilities were apparent: (1) the use of a single antenna for transmitting and receiving, (2) the combining of the telephone and television on a single channel, (3) a simplified switching arrangement, and (4) a simplified power plant.

These arrangements have been adopted. The first three are being used initially on several sections of the transcontinental system whereas the last one will be used on the over-all system.

The growing use of radar for defense, aeronautical, and meteorological purposes has necessitated serious consideration being given to possible interference to our microwave systems. Although the band in which these systems operate is outside that used by the telephone common carriers, side mode and harmonic radiation results in interference in the common carrier bands.

The National Research Council in Ottawa and the Bell Telephone Laboratories in the United States have carried out extensive tests to determine the extent of the interference problem. These tests, although not completed, indicate that a serious problem may exist unless means are taken to suppress radiation outside the frequency band allocated for radar operation.

Digest of paper 57-706, "The Canadian Transcontinental Microwave System," recommended by the AIEE Radio Communication Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Scheduled for publication in AIEE *Communication and Electronics*, 1957.

S. Bonneville is with The Bell Telephone Company of Canada, Montreal, Que., Canada.

Video Testing Techniques in Television Broadcasting

A. STE-MARIE

A discussion is presented of the practical effects on signal degradation of the parameters in a video transmission system. An attempt is made to establish their true significance and correlation. New video testing techniques have been established for improved and simplified methods of specification and measurement.

A TELEVISION video transmission system is basically a waveform transmission system. The prime objective is the preservation of the waveforms of signals on their journey from the camera to the home receiver.

It is inevitable that some distortion of the signal will occur in any practical transmission path. The amount of distortion which is permissible is based not on physical measurements alone, but on viewing tests by critical observers. Those physically measurable characteristics in which large variations cause no detectable difference in the quality of the received picture may be permitted large tolerance, while those to which the picture quality is particularly sensitive are permitted only small tolerances.

The following transmission parameters are usually taken into consideration:

1. Amplitude versus frequency characteristic.
2. Phase-delay versus frequency characteristic.
3. Transient response.
4. Differential gain and phase.

Although a substantial amount of effort has been devoted to determining the effects of these transmission factors on picture quality, especially in color transmission, much more work is required before the true significance of each parameter is known as well as establishing adequate correlation between them. More complete performance specifications are urgently needed for monochrome television systems and components.

New video testing techniques have been developed to meet the challenge although they are still by and large incomplete and, in many instances, lacking in the required degree of accuracy.

About two years ago, the tolerances in the FCC color television standards were tentatively divided as follows: 60% for the transmitter equipment, 20% for the studio equipment, and 20% for the studio-to-transmitter link. At that time, no reference was made to the intercity network facilities.

Several industry committees, including those of the Institute of Radio Engineers (IRE), Electrical Industries Association (EIC, formerly RETMA) and Canadian Radio Technical Planning Board, have been investigating this problem further, but progress has been slow to date. These same committees are also active in analyzing test equipment requirements and testing procedures.

AMPLITUDE FREQUENCY

THE AMPLITUDE VS FREQUENCY response of a video transmission system is a measure of the ability of the system to reproduce detail in the horizontal direction. It can be shown, assuming an ideal phase characteristic, that the maximum steepness of transitions in the picture and, therefore, picture sharpness is a function of the integral of the amplitude vs frequency response of the system, i.e., the area under the curve.

Picture quality is not appreciably affected by variations of the shape of the amplitude vs frequency characteristic in the vicinity of the cut-off frequency, as long as the average rate of change in this frequency range is not altered. However, in the substantially flat part of the amplitude characteristic, comparatively small variations with frequency cause echo effects in the picture.

In color television, tests have indicated that critical observers would rate one or two db amplitude variations in the region of the color subcarrier, with respect to low-frequency components, as "impairment to picture but not objectionable." Even smaller tolerances must be used at low frequencies to keep smearing and streaking down to a tolerable level for both monochrome and color transmissions.

It is generally advisable to use a reduced input voltage for frequency response measurements, in order to prevent overload conditions or other nonlinearities in the equipment under test from interfering with the measurement.

Special care must be taken when checking systems and/or components exhibiting peaks in the frequency response.

Sine-Wave Oscillators. Point-to-point sine-wave testing is by far the simplest and possibly the most precise method of measurement. It possesses the added advantage of providing for a complete coverage of the video frequency band.

However, it is a time-consuming process and one that

A special article recommended for publication by the AIEE Television and Aural Broadcasting Systems Committee.

A. Ste-Marie is with the Canadian Broadcasting Corporation, Montreal, Que., Canada.

The author wishes to thank J. E. Hayes and J. Carlisle for their encouragement and valuable assistance, and R. Fournier for his contribution in assembling the test data and preparing the slides for this article.

Fig. 1. Multiburst test signal. The sine-wave test frequencies are: 0.5, 1.5, 2.0, 3.0, 3.6, and 4.2 mc.

Fig. 2. Typical test result using the multiburst test signal. Circuit under test is the local video channel.

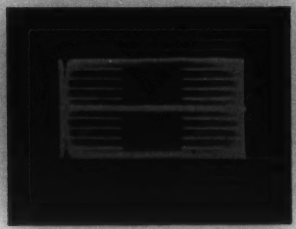


Fig. 3. Sweep generator output waveform. Single variable frequency marker is barely visible as small pip near top right corner.

cannot readily be used to check the performance of systems containing keyed clampers.

Multiburst Generators. The multifrequency burst generator (better known as the multiburst generator) produces a series of equal amplitude bursts of sine wave of various frequencies, usually extending from 0.5 mc to 6.0 mc. In addition, the output waveform includes sync and blanking pulses and a white bar signal (Fig. 1).

For quick checks, discrete sine-wave bursts of known frequencies are usually sufficient to show at a glance the general nature of the amplitude vs frequency characteristic. Test results are easy to tabulate and report. The test signal includes sync and blanking pulses and, therefore, will pass in the normal manner through the various television components and circuits.

The multiburst test signal is especially well suited for routine checks on systems. For this reason, it has been recommended for television network tests by the Joint Television Network Committees, grouping the Canadian Broadcasting Corporation, the Trans-Canada Telephone System, and the Canadian National and Canadian Pacific Telegraphs (Fig. 2).

Sweep Generators. Sweep generators provide a continuous display of the amplitude vs frequency response of the circuit under test. Sync and blanking pulses can readily be added to the swept sine-wave output of the generators. Combined with fixed-frequency markers, this test signal is as convenient as the multiburst test signal from the standpoint of tabulating, reporting, and comparing results. Swept signals are especially well suited for equipment and system alignment including equalizer adjustments, over-all studio system tests as well as routine checks on all video circuits (Figs. 3 to 6 inclusive).

PHASE-DELAY

In television transmission systems, the times of transmission of all frequencies in the video spectrum should be substantially equal. The transmission time over a system is known as the phase-delay or envelope delay and is expressed mathematically as the first derivative of the phase shift with respect to the frequency. If the phase is measured in radians and the frequency in radians per second, the phase-delay will be in seconds.

The time of transmission of a single-frequency wave through a system is called the absolute phase-delay or envelope delay of the system at that frequency, but it is not usually possible or necessary to measure this. The quantity that is of importance is the difference in phase-delay or envelope delay between signal components of different frequencies.

In discussing phase-delay distortion in television transmission systems, we must differentiate between the parts of the frequency spectrum in which the distortion occurs.

In the televised picture of a thin vertical line, for example, phase-delay distortion at the higher frequencies would be revealed by a displacement of the edges of the line and by one or more displaced images com-

Fig. 4. Sweep generator output waveform (10 fixed frequency markers, 1 mc apart).

Fig. 5. Typical equipment test result. Equipment under test: stabilizing amplifier.

Fig. 6. Typical system test result. Circuit under test: over-all studio facility.

Fig. 7. Sine-squared pulse (half amplitude duration: 0.125 microsecond).

Fig. 8. Sine-squared pulse (half amplitude duration: 0.250 microsecond).

Fig. 9. Complete test signal combining the sine-squared pulse and the white bar.

monly referred to as ringing. But with a wider object, only its edges would be affected by phase-delay distortion at the higher frequencies.

Constant phase-delay in a transmission system gives the best transient response possible for a given amplitude response. Delay distortion at the higher frequencies will also be accompanied by a corresponding decrease in the rate of rise of the transient response with a consequent loss in picture sharpness due to blurring of sharp edges.

A phase-delay distortion of 0.1 microsecond (μsec) of the higher frequency components in a television signal is readily apparent, and in actual practice, the phase-delay distortion at the higher frequencies should not be allowed to exceed approximately ± 0.5 μsec. Phase-delay distortions at the middle frequencies, from about 200 kc upwards, affect the definition of a picture markedly. This type of distortion is better known as smearing; the impairment is a blurring of the vertical edges of objects in the televised scene and the whole picture looks as if it had been smeared along the horizontal axis.

Finally, phase-delay distortions at the lower frequencies, from about 15 kc to approximately 200 kc, result in the most objectionable type of picture impairment, known as streaking.

It is quite certain that small delay distortions in the low and middle frequency band affect picture quality markedly, whereas they become of less importance as the upper frequency limit of the system is approached. Consequently, narrow tolerances should be placed on delay distortions in the low and middle frequency range.

In color television the subject of phase-delay distortion assumes additional importance because (1) misregistration of the luminance and chrominance signals in the reproduced color picture is an evident defect, (2) in receiving the color transmission on a monochrome receiver the compatibility will be impaired if the pattern resulting from the chrominance signals is not coincident with the corresponding luminance signal, and (3) abrupt delay variations occurring over rather small frequency increments in the upper portion of the video band can causes shifts in phase between various color components creating hue shifts.

It is difficult to measure relative phase delay to the required degree of accuracy. Most known methods of measurement apply only to the frequency range extending from approximately 500 kc upward. Phase-delay distortions occurring in the range from 15 kc to approximately 500 kc, cannot be measured conveniently at this time. This is indeed unfortunate since these distortions will cause impairments to the picture which are most objectionable in monochrome as well as in color transmission.

TRANSIENT RESPONSE

THE AMPLITUDE-FREQUENCY RESPONSE of a monochrome system is generally maintained fairly constant in order to assure a reasonable phase characteristic rather than to avoid a loss in picture detail. Although more important, the phase-frequency characteristic alone is not a complete measure of the waveform transmission capabilities of a system.

A television transmission system is basically a waveform transmission system, i.e., a system in which it is important to preserve the waveforms of signals. Transmission performance is better expressed by the waveform responses to suitably chosen test signals because they can more directly be related to picture quality, even though, from a mathematical point of view the steady-state (amplitude and phase) and waveform responses are equivalent in that a full knowledge of either enables the other to be calculated. Square-wave testing was introduced early in television transmission work. Among the pioneers of waveform testing in television were Puckle in 1935 and Bedford and Fredendall in 1939 and 1942. However, progress has been slow and waveform testing and specifying has not yet become common at least on this side of the Atlantic.

Sine-Squared Pulses. In the recent years, sine-squared pulses have been substituted for square-waves. A sine-squared pulse has the property of containing relatively large amplitude components of frequency up to a certain frequency, and only small components of almost negligible amplitude above that frequency. If the half-amplitude duration of the pulse is equal to $\frac{1}{2}f$, the response is down 6 db at a frequency f. Further, the frequency spectrum is zero at $2f$. For example, if f is chosen as 4 mc (the nominal television bandwidth) the corresponding half-amplitude duration is 0.125 μsec. The spectral response of this pulse is 6 db down at 4 mc and is 0 at 8 mc (Fig. 7).

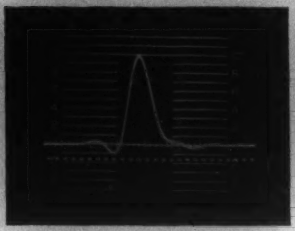


Fig. 10. Response of a video local channel to the 4-mc sine-squared pulse.

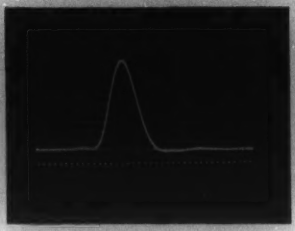


Fig. 11. Response of the same video local channel to the 2-mc pulse.

Fig. 12. Amplitude response of the same video local channel. Marker set at 4.2 mc.

An ideal square-wave, intended for testing a system over the upper part of the frequency range, generally produces a waveform response which includes a substantial amount of irrelevant information tending to obscure the relevant. The effect is minimized by using a sine-squared pulse, having an amplitude-frequency spectrum which falls away as rapidly as possible above the nominal upper cut-off frequency of the system under test. Furthermore, if the half-amplitude duration of the pulse is made $1/f$ or 0.25 μsec, its spectrum is down 6 db at 2 mc and is 0 at 4 mc (Figs. 8 and 9).

The particular merit of the latter pulse is that it is capable of being transmitted without distortion through an ideal low-pass system with an upper cut-off frequency of 4 mc. In other words, the response of a typical 4-mc television system to this pulse contains practically no irrelevant information. It is then especially well suited for routine tests on such systems. However, these test waveforms and others can be used to advantage only if adequate correlation has been established between waveform response characteristics on the one hand and picture quality on the other. Ideally, the performance specifications for any component or part of a system should be based on subjective picture appraisal determinations of the maximum amount of waveform distortion tolerable in a complete television system and subsequent allocation of fractions of this amount to each link. In actual practice, due attention must be given to results known to be attainable with some regard to economy. Once the performance specifications are agreed upon, waveform responses can be evaluated at a glance. Suitable oscilloscope masks can be devised for this purpose.

Amongst the features of sine-squared pulse responses usually specified are the maximum allowable half-amplitude duration and the maximum tolerable overshoots and undershoots, leading and trailing (Figs. 10 to 12 inclusive).

Although waveform techniques are remarkably simple and meaningful, there remains a serious drawback. Should the transient response fall outside the limits specified, it usually becomes necessary to revert to steady-state measurements in order to secure quantitive data on the amount of amplitude and/or phase distortion present. This is so, mainly because, in the present status of the art, components and systems are specified throughout the industry in terms of steady-state responses and alignment procedures are based on this more conventional approach. However, the newly developed waveform-synthetizing and waveform-correcting networks of the "time equalizer" and other types will allow one to operate directly on the waveform response.

Window Test Signal. Rectangular pulses, at field and line rates, are now in common use for checking the low-frequency transient response of television components and systems. A typical test signal is the "window" signal, so-called because it produces a white window on a dark background when displayed on a picture monitor (Fig. 13).

Originally developed to help locate streaking, the "window" test signal will provide a ready measure of the transmission performance at the lower end of the video spectrum. It is an extremely useful tool in television transmission work, especially in view of the lack of suitable methods of measurement of the amplitude and phase responses in that portion of the video spectrum.

The "window" test signal embodies sync and blanking pulses and, therefore, can be used to check the overall, as well as any part of the television system.

As pointed out earlier, streaking is caused by transmission irregularities in the frequency region up to about 200 kc and will, therefore, be detected by the use of the "window" signal. Streaking is a typical television picture defect that affects almost equally both color and black-and-white signal transmission.

Distortions that cause streaking can occur in any part of the transmission system from the camera to the television receiver. Prevention of these defects requires very close control of transmission characteristics in the lower frequency portion of the video band (Fig. 14).

A 5-degree phase shift or 1 μsec delay at the fundamental frequency will cause a tilt of approximately 24% in the "window" test signal corresponding to an intolerable amount of streaking in the transmitted picture.

As a matter of fact, a 5% tilt will result in distortions readily noticed during normal picture transmission, and

Fig. 13. Window generator output waveform.

Fig. 14. Example of negative streaking.

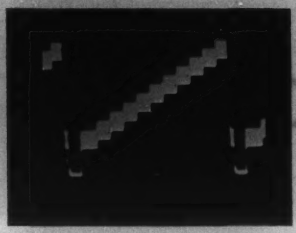


Fig. 15. Output of stairstep generator.

defects corresponding to as little as 2% tilt may be detectable under certain conditions.

DIFFERENTIAL GAIN AND DIFFERENTIAL PHASE

THE FOLLOWING DEFINITIONS have been extracted from the IRE Standards on Television; definitions of Television Signal Measurements Terms, 1955.

Differential Gain: In a video transmission system, the difference in the gain of the system for a small high-frequency sine-wave signal at two stated levels of a low-frequency signal on which it is superimposed.

Differential Phase: In a video transmission system, the difference in phase shift through the system for a small high-frequency sine-wave signal at two stated levels of a low-frequency signal on which it is superimposed.

The term "level" is used here to define a specified position on an amplitude scale applied to a signal waveform. If the foregoing definitions are accepted, it is redundant to speak of differential gain distortion or differential phase distortion, inasmuch as differential gain or differential phase is distortion. Both differential gain and differential phase are zero for an ideal transmission circuit. In monochrome television, differential phase has little significance if any. Differential gain, on the other hand, is a measure of the departure from linearity of the transfer characteristic of the transmission system. In severe cases of differential gain this form of distortion will result in either white compression or black compression or a combination of both. Small amounts of differential gain have but little effect on picture quality.

In color television transmission, it is an entirely different story. Because the transmitted luminance component and the chrominance components should be independent of each other, it is evident that the chrominance components must not be affected by the luminance.

Otherwise, for example, as an actress walked from the dimly lighted edge of a scene to the brightly lighted center, the color of her dress would change strangely.

The color subcarrier signal component being transmitted by adding it to the luminance or monochrome component, it follows that the average luminance level determines the a-c axis of the subcarrier.

Therefore, the desired independence of chrominance and luminance signals means that the change of gain of the subcarrier as a function of signal level, as well as the change of phase, should be zero. In other words, the differential gain and the differential phase should both be zero. Differential gain will cause a change in saturation of the colors whereas differential phase will be responsible for a change in hue. Of the two types of distortion, the latter obviously is the more objectionable. The average viewer is usually critical of hue shifts, especially when flesh tones and objects of readily identified colors are being reproduced. It is well known that a phase shift of about ± 5 degrees at the color subcarrier frequency is readily detectable.

The definitions presented for differential gain and differential phase contain within themselves a suggestion as to a basic measurement technique. Differential gain and phase can be measured with the aid of a test signal having two essential components, a low frequency "exploratory" signal of sufficient amplitude to explore the entire amplitude range of the system, plus a high-frequency sine wave of relatively small amplitude superimposed on the exploratory signal. The test signal should preferably be a synthetic television signal, containing synchronizing and blanking pulses, which can be passed through all normal transmission circuits. (Fig. 15).

For differential gain measurements, the output of the equipment under test is applied to an oscilloscope scanning at half the line frequency and through a high pass filter which will remove the low-frequency exploratory signal and leave the subcarrier oscillations (Figs. 16 and 17).

At this time, it would do to stress an apparent deficiency in the definitions of differential gain and differential phase quoted earlier. As will be remembered, the definitions refer to the difference in gain and phase of the system for a small high-frequency sine wave signal at two stated levels of a low-frequency signal on which it is superimposed. Whatever these two stated levels are, say blanking and reference white levels, the measured amounts of differential gain and differential phase at these two levels may yield an incomplete and inaccurate picture of the transmission performance of the circuit under test. As a matter of fact, it can be shown that under certain conditions, relatively small amounts of differential gain and differential phase can be measured

Fig. 16. This is the signal pattern of Fig. 15 after having passed through a high-pass filter.

Fig. 17. This display illustrates differential gain measurements. Differential gain is approximately 33% (white compression).

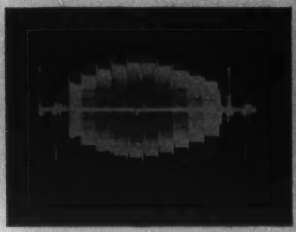


Fig. 18. Typical oscilloscopic signal display when both white and black compression are present.

between two stated levels of the low-frequency signal while it is evident that large amounts of differential gain and differential phase actually exist when the over-all amplitude range of the picture signal is taken into consideration (Fig. 18).

The following alternate definitions are recommended:

Differential Gain: In a video transmission system, "differential gain" is the maximum difference in gain of the system for a small amplitude high-frequency sine wave, the a-c axis of which is varied from blanking to peak-white level by means of a low-frequency exploratory signal on which it is superimposed.

Differential Phase: In a video transmission system, "differential phase" is the maximum difference in phase shift through the system for a small amplitude high-frequency sine-wave the a-c axis of which is varied from blanking to peak-white level by means of a low-frequency exploratory signal on which it is superimposed.

Differential phase can be measured by means of a high-pass filter coupled to a synchronous detector, in which the phase of the subcarrier component of the test signal is compared with that of a continuous reference subcarrier signal. A cathode-ray oscilloscope can be used as a null indicator at the detector output, and phase differences between the unknown and the reference subcarrier can be measured with a calibrated phase shifter. The reference subcarrier is usually extracted from the test signal itself.

CALIBRATION OF TEST EQUIPMENT

THE NEED FOR ADEQUATE CALIBRATION of the test equipment cannot be too strongly emphasized.

Voltmeters and oscilloscopes must be checked for voltage calibration. This may be done conveniently, using a suitable substandard voltmeter, specified to the required order of accuracy.

More important still is the calibration of the amplitude vs frequency response of the oscilloscope.

A useful device for the calibration of oscilloscopes is the Western Electric type *70B* transmission measuring set. It is a thermocouple-operated power measuring meter designed to operate in the frequency range from direct current to 10 mc. The accuracy in terms of absolute power expected at 0 db on the meter scale is ±0.1 db, whereas the differential accuracy over the entire frequency range is within +0.1 db.

Such an instrument not only is extremely useful for the calibration of oscilloscopes, but also will permit making direct point-to-point measurements on individual amplifiers, equalizers, cables, and other system components whenever a higher degree of accuracy may be required.

The frequency calibration of multiburst generators, sweep generators, and sine-wave oscillators should be checked with adequate care. One will understand that test results can hardly be correlated if the test frequencies cannot be ascertained within reasonable limits. Frequency calibration usually can be performed to a sufficient degree of accuracy without recourse to expensive and bulky frequency measuring equipment.

Oscilloscopes used for waveform testing especially sine-squared pulse measurements must be carefully calibrated along the time axis. Marker generators used for this purpose should preferably be crystal controlled.

REFERENCES

1. Routine Tests and Alignment Procedures for Amplifiers and Circuits Used for Color TV, H. C. Gronberg. NARTB Engineering Conference, Chicago, Ill., May 1954.

2. Apparatus for the Measurement of Phase-Delay in Television Transmission Circuits and in Associated Equipment, C. W. Goodchild, R. C. Looser. Institution of Electrical Engineers, *Proceedings*, 1952, Vol. 99, Part IIIa, pp. 788-95.

3. Color-Video Envelope-Delay Measurement, R. C. Kennedy, H. French. Electronics, New York, N.Y., June 1955, pp. 144-48.

4. Color Test Equipment and Test Procedures, J. W. Wentworth. Broadcast News, vol. 90, Aug. 1956, pp. 46-51.

5. Color Video Tester Checks Distortion, H. P. Kelly. *Electronics*, New York, N.Y., Sept. 1954, pp. 128-31.

6. Analysis, Synthesis and Evaluation of the Transient Response of Television Apparatus, A. V. Bedford, G. L. Fredendall, *Proceedings* of the Institute of Radio Engineers, New York, N.Y., Oct. 1942, pp. 440-57.

7. Spectrum Analysis of Transient Response Curves, H. A. Samulon. *Proceedings*, Institute of Radio Engineers, Feb. 1951, pp. 175-86.

8. A Theory of Time Series for Waveform Transmission Systems, W. E. Thomson. Institution of Electrical Engineers, London, England, Monograph, No. 53, Oct. 15, 1952, pp. 397-409.

9. Waveform Computations by the Time-Series Method, N. W. Lewis. *Proceedings*, Institution Electrical Engineers, London, England, 1952, vol. 99, part III, pp. 294-306.

10. Waveform Responses of Television Links, N. W. Lewis. *Ibid.*, July 1954, vol. 101, part III, p. 258.

11. A Testing Pulse for Television Links, I. F. MacDiarmid. *Ibid.*, 1952, vol. 99, part IIIa, pp. 436-44.

Electric Analog Circuits for Exact Economic Dispatch

R. B. SHIPLEY
FELLOW AIEE

INFORMATION NEEDED to determine generation schedules is similar to that used for an a-c network analyzer load flow study except that incremental cost data is used instead of generator schedules.

The circuits give the generator power schedules that result in minimum fuel cost and the generator reactive requirements that maintain preassigned generator bus voltages. The incremental cost of power delivered to any bus on the system can be determined. Furthermore, any system conditions that can be determined from a conventional a-c network analyzer load-flow study also can be determined from this circuit.

The actual power transmission system is represented in miniature. Changes in the transmission system can be made similarly to the way that they are made on the a-c network analyzer. A change in fuel cost can be introduced by changing a transformer ratio. Any load on any load power factor can be changed at any time. The circuits are adaptable for manual or automatic operation. Equations

$$P = (E_{ref} - ZI)_t I^* \tag{1}$$

$$C_{ref} = C\left(1 - \frac{2}{e_{ref}} RI_r\right) \tag{2}$$

describe the conditions that must exist on the power system to supply the loads at minimum fuel cost. Equation 1 describes the conditions that exist on the network when the loads are supplied by some given generation schedule. This equation is always solved in some form when any computing device performs a load-flow study. Its solution also exists on the actual power system. Equation 2 describes the conditions that exist between the real components of bus currents when the loads are supplied at minimum generation cost. This equation does not describe the quadrature components of currents. These components generally are closely related to bus voltage and are dictated by operating requirements rather than maximum fuel economy.

The a-c network analyzer solves equation 1 in such a manner that all of the quantities used in the equation exist in measurable form when the analyzer is brought into load-flow balance. Certain quantities needed in equation 2 are available on the network analyzer, but the RI_r product is a derivative which present analog computers have only approximated. It is the invention of static electric analog circuits to give this product directly that enables the economic dispatch problem to be solved completely and exactly.

Equation 1 describes how the power system performs under load-flow conditions. Because this information is desired, the circuits must solve equation 1. Close examination of equation 2, with minor changes in the grouping of variables, will indicate several circuits that solve it. Some of the circuits are adaptable for manual operation whereas others lend themselves to automatic operation.

Observe that the term $2R$ in equation 2 can be obtained as follows:

$$Z + Z^* = 2R \tag{3}$$

Z describes the transmission system, and for load-flow purposes it can be adequately represented by the use of a miniature model. Z^* is the conjugate of Z, and can be represented by another model in which the conjugate of each element of the transmission system is used. The term $2RI_r$ is the real part of the equation

$$(Z + Z^*)I = ZI + Z^* I \tag{4}$$

The term ZI describes the voltage drops that exist on the power system when carrying the bus currents I. Thus, equation 4 permits the synthesis of circuits that describe the power system under load-flow and also yield the $2RI_r$ product in measurable form.

Rearranging equation 2 gives

$$C_{ref}E_{ref} = C(E_{ref} - 2RI_r) \tag{5}$$

Note that equation 5 is a voltage restraint equation. If the circuit is designed to follow this equation as applied to the generating stations, then the system can operate only in economic balance. The essentials of the computing circuit for the economic dispatch problem are shown in Fig. 1.

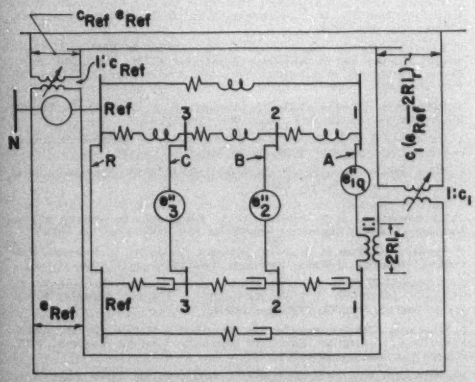


Fig. 1. Essentials of computing circuit for the economic dispatch problem.

Digest of paper 57-680, "Electric Analog Circuits for Exact Economic Dispatch," recommended by the AIEE System Engineering Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1957.

R. B. Shipley is a consulting engineer in Chattanooga, Tenn.

Radio Frequency Spectrum Management

C. M. BRANT

THERE ARE ABOUT 48,000 radio stations in service in Canada. This is five times as many as were in existence in 1948. Canada is the third or fourth greatest user of radio among the countries of the world.

Two of the basic philosophies of spectrum management are: (1) to restrict the type of service for which the use of radio is permitted and, thus, restrict the demand to fit the spectrum; and (2) to permit the use of radio for any communication requirement which cannot be reasonably and economically satisfied by other means. It is the latter philosophy which the Department of Transport endeavors to follow. The spectrum is limited—some way must be found to accommodate the increasing number of radio stations. Canada believes that the solution lies in the advances being made in new techniques which provide opportunities for greater utilization of the spectrum as spectrum loading increases.

The International Telecommunications Union sets minimum technical standards governing those characteristics of radio transmitting stations which affect frequency spectrum utilization. In the main, these standards are designed to take care of the effect of radio emissions of one state upon another.

However, most countries set standards for themselves which are higher than those of the International Telecommunications Union and which are designed for spectrum economy not only with regard to the international picture, but also with regard to special domestic problems.

In Canada, this is done by the development of technical specifications governing the suitability of radio equipment for licensing for various services. The specifications are intended to represent a technical level of excellence which is reasonable in the present state of the art.

They are of four general types: (1) those designed for standardization of techniques or methods, where compatibility of radio stations in a like service is important; (2) those governing technical factors which have an effect upon spectrum management or frequency economy; (3) those which in addition to the second point also govern the reliability of radio equipment to be used for safety services, such as aeronautical mobile and maritime mobile; and (4) fact-finding specifications which cover mainly services or applications not already covered by detailed specifications of the type previously mentioned.

It is believed that the aeronautical world will have to find its own solution for additional spectrum space by the use of single sideband radiotelephone techniques and the rechanneling of its bands to provide for more frequency channels. It is considered that an attempt to obtain more high-frequency spectrum space would be unsuccessful.

Because of fixed service congestion on high frequencies, it is possible that at the next conference of the International Telecommunications Union there will be a drive to allot priorities for frequencies of this order. It is felt that circuits will have to take advantage of single sideband techniques. Many of the shorter circuits will have to be transferred to much higher frequencies.

If the ionospheric scatter technique is to be used, extensive portions of the 30- to 50-mc band will have to be cleared and it is of some concern to the Department that the displacement problem, i.e., the large number of services which will have to be moved in this clearing process, does not seem to be fully understood by those who are supporting extensive use of ionospheric scatter.

There are no bands allocated for the tropospheric technique in the Atlantic City Table. There is a band between 4,200 and 5,000 mc which is rarely used in Canada and this would seem appropriate for the use of tropospheric scatter, if suitable equipment can be developed. The problems of both tropospheric scatter and ionospheric scatter will be gone into very seriously at the forthcoming conference of the International Telecommunications Union in 1959.

The point is made that it is always necessary to consider the spectrum utilization problems when considering a new technique.

There is, as yet, no international agreement on the use of very-high-frequency channels (vhf) although a group of countries in Europe are attempting to advance the idea of an international maritime mobile vhf service.

The Canadian administration believes that a certain minimum number of vhf channels should be laid down whereby ships of any nationality can obtain service at any port anywhere in the world for: (1) emergency and calling, (2) port operations, (3) public correspondence, and (4) intership working.

It may be necessary in the not too distant future for applicants, particularly those proposing complex systems, to avail themselves of technical consultant services.

It is recognized that the manufacturing industry, the user, and the administration all want the same long-term result and it is suggested that all should be prepared to give ground on what might appear to be a quick expedient short-term solution to problems, to maintain informality, to sit down at meetings, perferably in small groups which can make some progress, and to discuss freely mutual problems with the aim of a well-managed spectrum, a thriving manufacturing industry, and a satisfied user.

Digest of paper 57-647 "A Canadian Point of View on Radio Frequency Spectrum Management," recommended by the AIEE Radio Communication Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Scheduled for publication in AIEE *Communication and Electronics*, 1957.

C. M. Brant is controller, Radio Regulations Division, Department of Transport, Ottawa, Ontario, Canada.

Telemetering in Earth Satellites

WHITNEY MATTHEWS
MEMBER AIEE

Varied experiments proposed for the earth satellite require a very flexible telemetering system designed for maximum reliability and minimum weight and operating power requirements. A new instrumentation technique combining square hysteresis loop magnetic cores with switching transistors is discussed in the description of the magnetic telemetry encoding system.

THE REQUIREMENTS for a telemetering system for the earth satellite are, in general, much the same as in any telemetering system but with a greatly magnified importance attached to many of the problems. Qualities which are normally desirable have become essential. Cost of placing a satellite in an orbit, long telemetering life and impossibility of maintenance place a tremendous emphasis on reliability. Weight reduction is mandatory due to the terrific penalty in vehicle weight required to place each additional ounce into the orbit. Operating power requirements must be held to an irreducible minimum because long operating periods are required from self-contained batteries.

One major new problem introduced into the telemetry system requirements for the earth satellite scientific program is that of memory devices. Inclination to the plane of the earth's equator for the proposed orbit of the satellite is such that it will pass over nearly two thirds of the earth's surface. Provision of an adequate number of ground stations to receive and record telemetered data over all of this area is not feasible. With any practical number of ground stations, the very nature of many of the scientific phenomena to be studied are such that there is little statistical likelihood of obtaining significant data during the recording intervals. Memory devices are thus indicated for storage of information collected during an orbit and subsequently recorded during transit of the satellite over an established ground station.

The very listing of the requirements for an earth satellite telemetering system calls to mind the prime attributes of one or more of the recent advances in magnetic devices. Weight and power efficiency coupled with a high degree of reliability have characterized magnetic amplifiers since the introduction of modern magnetic materials. More recent advances using a combination of square hysteresis loop magnetic cores with switching transistors has made available a new and flexible instrumentation technique. Use of magnetic techniques for storage of information is commonplace. From this background, a program was initiated to create a magnetic telemetry encoding system for use in the earth satellite.

Whitney Matthews is with the Naval Research Laboratory, Washington, D. C.

The earth satellite will use the Minitrack radio tracking system for determination of time–position information. Amplitude modulation of the Minitrack transmitter in the satellite will be used as a radio link for transmission of data to the recording sites. A telemetry encoder using magnetic techniques will be used to scan the various input information channels and modulate the Minitrack transmitter with a signal from which the input data from scientific instruments in the satellite can be extracted.

BASIC PRINCIPLES

THE TELEMETRY ENCODER uses square hysteresis loop core materials to establish a series of time intervals proportional to a series of input parameters from satellite instruments. Consider a hysteresis loop of the general character shown in Fig. 1 with the flux level at positive saturated remanance point A. A voltage of proper polarity applied to a winding on such a core will cause the flux to approach point B as shown by arrow 1. Inasmuch as the voltage induced in the winding, due to this change of flux, must equal the applied voltage in an ideal case, the rate of change of flux must be a linear function of the applied voltage and the current flowing in the winding will be limited to the value, I_M. In other words, such a core is capable of absorbing a fixed number of integrated volt-seconds in changing its flux level from point A to point B, or the time required to change the flux between these points is inversely proportional to the applied voltage. When the flux level reaches point B, radical changes take place in the core characteristics. Currents are no longer limited to I_M and any practical circuit cannot provide the large currents necessary to maintain the rate of change of flux required to have the induced voltage equal to the applied voltage. These characteristics at saturation are thus able to supply current and voltage signals to actuate switching transistors which change the core from one operating mode to another. Interaction of switching effects between the core and transistor provides a cumulative action to provide very rapid transitions between operating modes. Switching transistors are used to remove the applied voltage which provided the flux change from A to B and permit operating conditions to return to C. This same switching signal is used to apply a second (or the same) voltage of reversed polarity to repeat the aforementioned process in carrying the flux as shown by arrow 2 to its original condition at point A via point D. The foregoing discussion has been based upon a voltage source as a signal input, but minor changes permit use of variable resistances or currents as input signals.

An output winding placed on such a core would have an induced voltage proportional to the input signal,

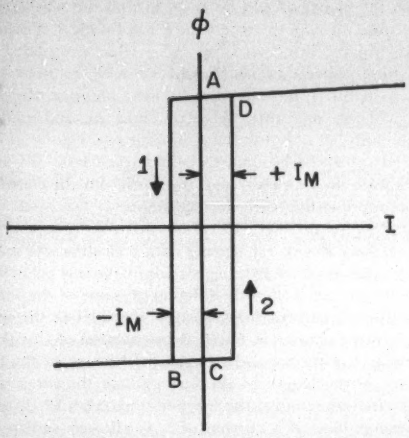


Fig. 1. Idealized flux-current relationships in a square hysteresis loop magnetic core material.

polarity a function of the direction of traversal of the hysteresis loop, and a time interval between reversal of output polarities inversely proportional to the integrated average of the signal input over that time interval. In the satellite telemetering system, this latter characteristic is used to present the useful data, thus eliminating stringent linearity requirements on the data transmission system and also permitting all data to be derived from a measurement of time which can be done with precision.

These basic characteristics are used in two ways in the earth satellite telemetry encoder system. In what will be called the "high-frequency" channels, the same input signal is used to carry the flux level around the entire hysteresis loop. Switching transistors are used at each saturation polarity to reverse the magnetomotive force applied by the input signal and return the core to its saturated flux level in the opposite direction at a rate proportional to the same input signal. For a fixed input signal, this circuitry would generate a symmetrical square wave, frequency of which is a function of the input signal. For a variable input signal, an unsymmetrical square wave of continuously variable time intervals between polarity reversals would be generated, each such interval representing the integrated average of the signal level during the interval. Relationships between signal levels and volt-second capacities of the magnetic circuit are so adjusted as to provide flux reversals at a rate which is orders of magnitude more rapid than the second usage to be described. For this reason, high-frequency channels will be used for all rapidly varying inputs requiring a good time resolution in their measurement.

The second type of information presentation is in the "time-interval" channels. This circuitry differs from the high-frequency channels previously described in that the switching pulse at saturation is used to transfer magnetic circuit inputs from one input device to another. Thus, the time required to go from positive to negative saturation is a function of one input, whereas the succeeding time interval is established by a second input carrying the flux level back from negative to positive saturation. A third input would be used in establishing the next flux transition from saturation to saturation, etc.

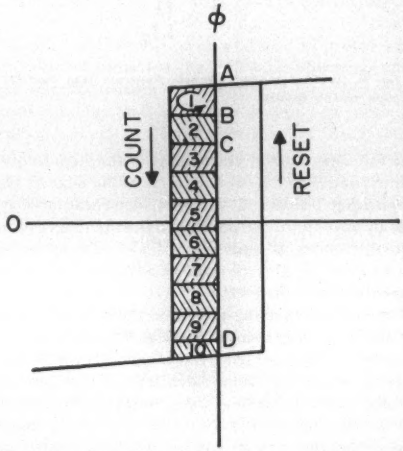


Fig. 3. Square hysteresis loop magnetic core material used as decimal counter.

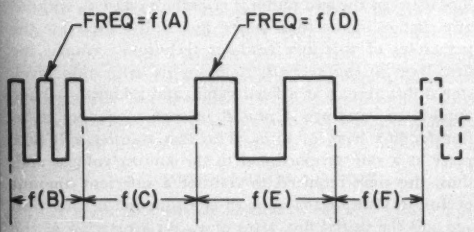


Fig. 2. Typical basic telemetering presentation.

With these basic functions, the general techniques of the earth satellite telemetry system may now be described in terms of a six-channel telemetry system.[1] Output signals after electrical clipping to provide uniform pulse heights would be as shown in Fig. 2 for one "frame" or scan of all channels. Upon completion of each frame, a subsequent frame would be presented, differing from the previous frame only as required to reflect changes in the input parameters. Such a system carries two information channels in the form of high-frequency bursts, two information channels in the time intervals during which these bursts appear, and the remaining two channels in the intervals between bursts, as shown. The switching signals

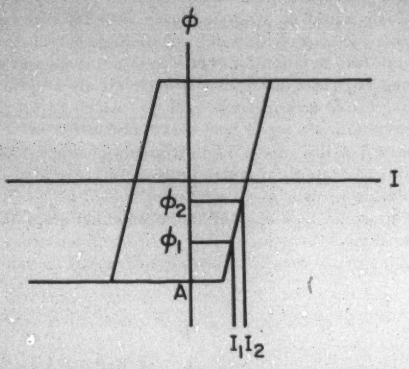


Fig. 4. Idealized skewed magnetic hysteresis loop used for peak memory devices.

from the time-interval channels gate the high-frequency channels and switch from one input to the next by means of switching transistors. Channel identification may be made by appropriate selection of dynamic ranges of high-frequency bursts or provision of always long or short time-interval signals, the latter usually in the form of fixed calibration channels.

Magnetic cores having this same general characteristic may also be used in memory devices. For example, Fig. 3 shows the technique used for a magnetic event counter[2] assuming a hysteresis loop identical to that previously discussed with the flux level initially at positive saturation point *A*. For each event to be counted, a fixed volt-second input is supplied to the winding which is slightly more than one tenth the volt-second capacity of the core. The first such input will thus change the flux level from *A* to *B*, the second pulse from *B* to *C*, etc. After the ninth such pulse, the flux level will be at *D*, so that the tenth pulse will cause the core to saturate at *E* to provide a switching pulse. Again, this switching pulse will be applied to switching transistors which will be used to reset this core to point *A* and advance the next identical decimal digit counter one unit. Magnetic cores are also used to fix the number of volt-seconds in each input pulse at the desired value. Techniques to be described later are used to indicate the flux level and, thus, read-out the count in a core representing each decimal digit.

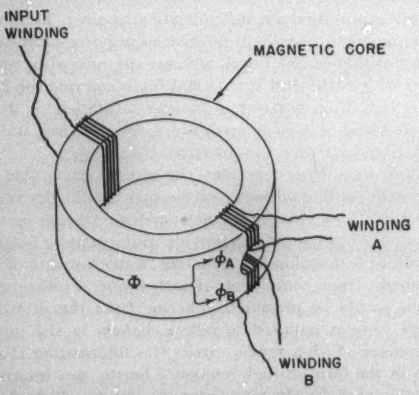


Fig. 5. Magnetic core and winding configuration for non-destructive flux read-out of memory devices.

Another requirement of certain scientific experiments is a memory device for storing data regarding the maximum value reached by a signal input during an orbit.[3] This device uses a slightly different concept of the idealized square hysteresis loop wherein the sides of the loop are skewed as shown in Fig. 4. Some amount of this skew is inherent in the torroidal cores used because of the difference in the length of the flux path at the inner and outer circumference of the magnetic material. With such a hystereis loop, if a current of I_1 is allowed to flow in the winding and subsequently reduced or removed, the flux in the core will assume a remnant value such as ϕ_1. Currents in the winding of value less than I_1 will make no further change in ϕ_1. If, however, the current at some later time exceeds the value I_1 and goes to a new value I_2, a new flux level such as ϕ_2 is established and retained. Thus, a read-out of flux level will provide information on the maximum value of winding current since last reset to point *A*.

The memory systems described store data as a magnetic flux level. This flux level could be determined by measuring the length of time required for a known voltage to change the flux level from its memory value to one or the other saturated flux levels. This technique would destroy the stored flux level in the process of read-out so that only one such read-out could be made. The very nature of the satellite experiment requires continuous data presentation over long periods of time and, therefore, a nondestructive method is needed for read-out of information stored as magnetic flux levels. The magnetic core configuration and winding arrangement used for nondestructive read-out of flux levels are shown in Fig. 5. The signals applied to the input winding establish the stored flux ϕ which is the desired function of the input signal. This stored flux path is divided into two parts by the small hole in the core through which two read-out windings, *A* and *B*, are inserted. These read-out windings are used in circuitry which permits a transfer of flux between the two minor flux paths ϕ_A and ϕ_B without any change in the total stored flux ϕ. To illustrate the principles of this flux read-out technique, assume the flux level in the ϕ_A path to be at its saturation level, stored flux level ϕ at a fixed value, and a known voltage applied to windings *A* and *B* in such a manner as to transfer flux from ϕ_A to ϕ_B. This flux transfer will take place at a rate proportional to the known voltage and, thus, the time required to transfer a sufficient amount of flux to saturate the ϕ_B path is a function of this voltage and the initial flux level of ϕ_B. At saturation of the ϕ_B path, a switching pulse as previously described is avail-

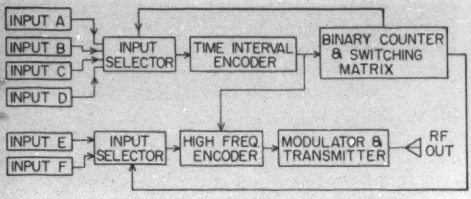


Fig. 6. Block diagram of generalized telemetering system.

able to reverse the winding polarities by means of switching transistors. Flux is now transferred from ϕ_B to ϕ_A until the ϕ_A flux resaturates and the foregoing process is repeated. To illustrate, two extreme conditions will be described. First, assume a large value of stored flux so that both ϕ_A and ϕ_B flux paths are nearly saturated in the same direction. For this condition, only a small flux transfer between the two flux paths is necessary to transfer saturation conditions. The short time required for transfer of small amounts of flux results in a high-frequency output. Second, assume a stored flux level at zero. Flux levels for a minor magnetic path around the small hole can assume any flux level from clockwise to counterclockwise saturation. Thus, the flux levels must be carried over a maximum excursion between two saturation levels, thereby involving maximum time of transfer or minimum read-out frequency. Intermediate values of stored flux ϕ provide, of course, intermediate output frequencies.

It will be noted that all transistors are used as switches and are, thus, operated in either saturation or cut-off conditions, except during the brief switching interval. Under these operating conditions, very little power is dissipated in the transistors leading to high efficiency and conservation power ratings with attendant long life and reliability. The use of transistors in this manner permits a system wherein accuracy and resolution are affected only by transistor switching time. This relegates to a second order effect changes or variations in transistors due to aging or manufacturing tolerance.

This discussion is intended to illustrate basic operating principles and is perhaps oversimplified, particularly in practical circuit details. The system in its entirety is complex and a reasonable general discussion cannot go beyond the block diagram stage. The idealized conditions assumed are quite closely approximated by practical materials and components. Many practical problems have been passed over lightly in the interest of providing basic concepts. For instance, nondestructive read-out of flux levels provides information on absolute magnitude but not direction of magnetization. Circuit modification or careful limitation of flux excursions are required, therefore, to eliminate possible ambiguities.

BASIC TELEMETRY ENCODER

A BASIC SIX-CHANNEL telemetry encoder system applying these principles is illustrated in Fig. 6. The upper group of four input devices are connected to the time interval encoder via an input selector. The input selector consists of four switching transistors turned on, one at a time in sequence, by signals from the switching matrix. Each input signal in turn is used to carry the flux level of the magnetic core of the time-interval encoder either up or down one side of the hysteresis loop at a rate which is a function of the individual inputs. The direction of traversal of the hysteresis loop determines the polarity of voltage appearing across an output winding which is used to activate and deactivate alternately the magnetic oscillator of the high-frequency encoder. A binary counter and switching matrix is activated by the switching signal available as the time-interval encoder magnetic core saturates. The binary counter and switching matrix provides signals to actuate input selectors for both high-frequency and time-interval encoders in proper sequence and combinations for the following operating schedule: (1) output frequency, a function of input *E*, continuing for a time interval which is a function of input *A*; (2) high frequency OFF for a time interval which is a function of input *B*; (3) output frequency, a function of input *F*, continuing for a time interval which is a function of input *C*; and (4) high frequency OFF for a period of time which is a function of input *D*. Upon completion of each such scan of all channels, a similar new scan would be immediately initiated. All information is carried in the output of the high-frequency encoder in the values of the frequencies and their time sequence. Thus, the transmitter modulation signal is taken directly from the high-frequency encoder.

A minimum telemetering system would consist of a three-channel system of one high-frequency burst and one blank space. Additional channels are added by providing one more binary counter and its associated switching matrix to double the previous number of channels. This system could be provided for 3, 6, 12, 24, 48, etc., chan-

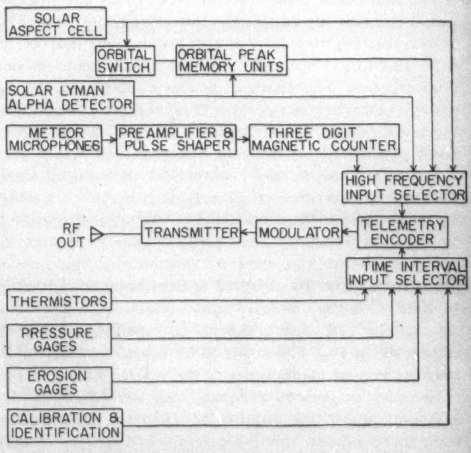


Fig. 7. Block diagram of telemetering system for the first satellite.

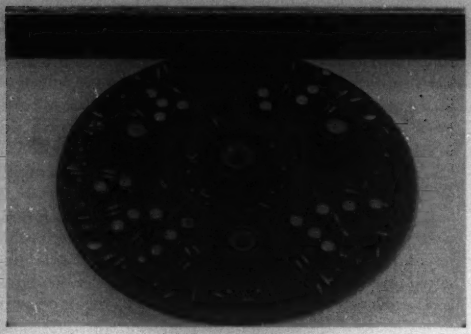


Fig. 8. Basic 48-channel telemetering system.

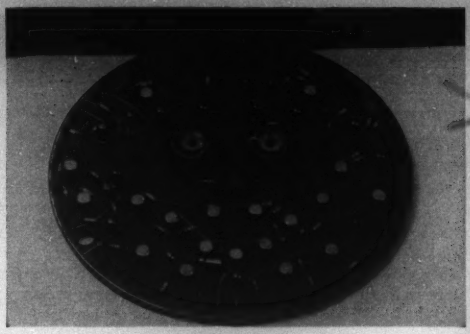


Fig. 9. Orbital peak memory unit with orbital switch.

nels of input information. Time-interval channels would be used for calibration and input signals having slow rates of change. High-frequency channels provide much improved time resolution for rapidly changing inputs and also are used for read-out of all magnetic memory channels. Minor modification to the switching matrix permits frequent reintroduction of one input signal into appropriately spaced channels where conditions demand.

FIRST SATELLITE TELEMETERING SYSTEM

THE FIRST SATELLITE to be launched as a part of the International Geophysical Year (IGY) will carry experiments to study the solar Lyman alpha radiation and the satellite environment. Of the measurements to be made on the environment, inputs will be slowly varying quantities with major changes expected only between successive orbits with no significant changes anticipated during any one brief telemetering record. For instance, surface temperature will most certainly change as the satellite passes through the earth's shadow after being heated by solar radiation during something over one half of its orbit and will be studied by measurements made on successive orbits. The changes of this temperature during a single telemetry record would convey little useable information. Solar Lyman alpha data will, on the other hand, require detail study of instantaneous values as a function of time in order to extract meaningful data. Not only is the value of solar Lyman alpha a variable, but it is additionally modulated by the spin of the satellite in such a manner as to provide solar Lyman alpha signals for only about one third of the time. This Lyman alpha signal must be obtained in detail and co-ordinated in time with the similarly spin-modulated output of a silicon solar cell used to determine satellite aspect with respect to the sun. From this information, necessary calibrations may be made to derive the desired data.

In order to present adequate data on Lyman alpha and solar aspect, the number of telemetry channels has been increased and this information is displayed several times during each scan of all channels. This information is also presented on high-frequency channels to give detailed information on these signals as a function of time during each "view."

The first satellite telemetry system will provide 48 information channels consisting of 16 high-frequency bursts and 32 time-interval channels. Of the 16 high-frequency bursts, 12 are used to provide adequate instantaneous data for the solar Lyman alpha detector and its associated aspect cell. Neglecting duplication of channels as required by the Lyman alpha experiment, the general system block diagram is shown in Fig. 7. One additional high-frequency channel is utilized for presentation of an orbital peak value for the solar Lyman alpha detector. This channel utilizes the magnetic peak memory units previously described for a study of anticipated abnormally high values during solar flares which occur infrequently and at random and, therefore, could not be monitored with any certainty by fixed ground recording stations.

The remaining three high-frequency channels are used to read out three decimal digits of a magnetic counter storing information concerning collisions with micrometeorites. Sensitive microphones are used as accelerometers to detect collisions with these particles. Microphone output is amplified and a pulse shaper is used to feed the appropriate signal into the magnetic counter to advance one decimal digit for each such collision.

For this telemetry system, all time-interval inputs are supplied by variable resistance input devices. Required display times for associated high-frequency channels are controlled by appropriate selection of nominal resistance values of input devices and their excursion is held within necessary limits by use of parallel fixed resistors. Thermistors are used to measure surface temperatures at the pole and on the equator as well as the internal instrumentation compartment temperature. Two pressurized zones are provided and pressure gauges installed to detect puncture of these zones by micrometeorites having sufficient energy to penetrate the outer shell. Surface erosion will be studied by monitoring the resistance of

exposed thin film resistance elements. Calibration channels used to monitor battery voltage and fixed resistance values will also provide a code for channel identification by a fixed sequence of a long burst followed by a short blank interval.

This basic telemetry encoding system has been a custom design for this particular group of experiments and compatible operation with the radio tracking system. The basic 48-channel telemetering encoder weighs approximately 3.2 ounces and requires under 12 mw operating power (4 milliamperes at 2.7 volts). The low operating power permits continuous operation for a period in excess of three weeks with batteries weighing 2.8 ounces. The telemetering system occupies a printed circuit card 5½ inches in diameter and ¾ inches maximum height, as shown in Fig. 8. The entire assembly will be cast in plastic foam for satellite installation.

For this installation, time-interval channels will lie between 5 and 30 milliseconds duration and high-frequency channels between 5 and 15 kc. These values have been dictated by considerations other than limitations in the telemetry encoder. The upper limit of the high-frequency channels was set by signal-to-noise considerations in this system which involves use of low transmitted power over long distances which necessitates narrow noise bandwidths. The 5 kc lower limit for the high-frequency channels was determined by frequency components in the signal which would introduce excessive errors in the radio tracking system. Similarly, extreme values for the time-interval channels were dictated by consideration of the maximum time allowable for scanning all channels and the minimum number of cycles in each burst to permit accurate data extraction. With these system parameters, a complete scan of the 48-input channels will be made approximately twice each second.

Laboratory tests on system reproducibility indicate that accuracy limitations will be determined by signal-to-noise ratio problems in the radio transmission link.

The peak memory circuit and orbital switch are mounted on a single card identical in size to the telemetering encoder and weighs approximately 2.5 ounces. This unit is shown in Fig. 9.

REFERENCES

1. "Earth Satellite Telemetry Coding System Using Transistors and Magnetic Cores," R. W. Rochelle. 1957 National Telemetering Conference Report, Naval Research Laboratory, Washington, D. C.

2. "Magnetic Core Event Counter for Earth Satellite Memory", D. H. Schaefer. Ibid.

3. "Commutation and Nondestructive Read-Out of Magnetic Memory Cores in Earth Satellite," C. B. House. R. L. Van Allen. Ibid.

The Digital Computer and Power System Short-Circuit Calculations

M. J. LANTZ
MEMBER AIEE

Precalculation of short-circuit currents is necessary in order to provide effective protection of power systems against possible short circuits. A method for determining these currents by means of a digital computer is described. Among its advantages are speed, accuracy, and the ability to be operated without highly trained professional personnel.

ADEQUATE PROTECTION of a power system against the inevitable short circuits that occur requires detailed precalculation of short-circuit currents at the possible locations of these faults on the system. Normally, the 3-phase short circuit and the single-phase-to-ground short circuit with distribution of currents in the network, at least one bus away from the fault, are required. A bus fault at each voltage bus for each station is calculated, as is a fault on each set of terminals for each line circuit breaker after the breaker has opened. The bus fault provides the maximum short-circuit current the relays see prior to the opening of any circuit breaker. The fault on the line-side terminals of the breaker after it has opened shows the minimum short-circuit current, neglecting fault resistance that can normally be expected through the breaker on the unopened end of the line for final isolation of the faulted line. The fault on the bus-side terminals of the line breaker, after it has opened, shows the maximum short circuit through the breaker for a line fault if the breaker is reclosed on the isolated line and the fault is still present. It also often produces the maximum interrupting duty on the circuit breaker.

Full text of conference paper CP57-912, presented at the AIEE Pacific General Meeting, Pasco, Wash., Aug. 28-30, 1957, at a session sponsored by the AIEE Relays Committee.

M. J. Lantz is with the Bonneville Power Administration, Portland, Oreg.

The currents that are calculated are symmetrical rms values and neglect the fault resistance and station mat resistances for the ground faults. The general method as proposed by AIEE is the commonly accepted procedure for general high-voltage network problems. This assumes one per-unit internal machine voltages, all voltages in phase, and the subtransient machine reactance for all synchronous machines. Normally, the scalar impedance of the transmission line is used.

Factors of asymmetry may be considered when necessary and considerable study of these have been made for the Bonneville Power Administration system.[1,2]

The approach for the determination of the required short-circuit currents are mainly four, as follows:

1. Desk calculation
2. D-c network analyzer
3. A-c network analyzer
4. Digital computer

The use of the first three have been standard, their selection being a function of the availability of equipment and the complexity of the problem. The latter method is new and was developed by the author.[3]

Modern power systems are extensive and complicated particularly for the ground faults. Several transmission lines are often built on the same right of way. For the ground faults, the zero-sequence components of the short-circuit current are all in phase, and two adjacent transmission lines act as a single-turn air-core transformer. Voltages are induced during the fault from one circuit to the other, their magnitudes being a function of the coupling and ground currents. These voltages may affect the fault-current magnitudes to a considerable degree. Some of the effects of mutual induction for ground faults on transmission lines have been described previously.[4]

Several equivalent circuits have been determined for adapting the less complicated mutually coupled networks for either calculation or use on the d-c network analyzer. It has been necessary to resort to the a-c network analyzer for most of the more complicated mutually coupled networks which are numerous in our system and other systems such as the City of Seattle high-voltage network. The work load on the a-c network analyzer often considerably delayed solutions of the short-circuit problems, and if certain faults were overlooked or errors made after the study was completed long delays were encountered before additional data or corrections could be made.

The advent of the digital computer and the development of a method of solution of short circuits on networks including these complex mutually coupled networks has been most timely for our use. Many advantages are present in the digital solution over the use of the analyzer. The detail of the method will not be covered here.

The digital computer method for short-circuit calculation has been programmed for the IBM *650* and is fully automatic. The cards are prepared for a complete study for all the faults desired on a network. A single deck of cards is fed to the computer and all short circuit currents in the network for each fault and the fault impedance is automatically calculated and punched on cards. No computer attention is required until the complete study is finished. The answer cards are then tabulated and the printed results are ready for use.

The present method uses all impedance values in the noncomplex form which is normal for the majority of short-circuit calculations. Negative values as well as positive values of impedance may be used. Often one leg of a 3-winding transformer impedance is negative or a series capacitor is a negative reactance.

Use is made of the d-c network analyzer for reducing parts of the system to terminal equivalents for the limited area under study. It is always desirable to keep the area under study as small as practical to obtain a minimum solution time per fault. Breakers may be opened or closed as desired and all of the types and locations of faults previously discussed may be obtained.

The method permits ready evaluation of any number of mutually coupled circuits consistent with the limitations of network size that can be handled. The present program is capable (with the automatic feature) of solving a 20-by-20 matrix, which is equivalent to a network having from 36 to 50 impedance elements, the number being a function of the network arrangement. This is exclusive of the mutual impedance elements.

The time of solution per fault is a function of the matrix size to be solved and is equal to approximately $0.0012\ N^3$ minutes, where N is the matrix size, plus approximately ½ minute for general calculation and readout time. Most areas of our present system can be reduced in size for calculation to within 1 to 5 minutes per fault, which is equal to or less than the average time per fault on an analyzer. The preparation time for a study is also comparable to or less than that required to make an analyzer study.

One major advantage is that once the study is prepared, an engineer's services are not required to obtain the results, as is necessary on an analyzer. If data is omitted or an error is later detected, it is necessary only to rerun a few cards for the desired answers.

System alterations are readily made, once an area has been prepared for the computer by altering a few cards and rerunning the study.

FAULT LOCATION CALCULATIONS

FOR FAULT LOCATION WORK, usually applied only to ground faults, it is required to calculate intermediate positions of faults along the length of transmission line before the circuit breakers have opened. The ratios of measured short-circuit currents give a good indication of the fault location when compared to precalculated values.[5] The effect of fault resistance is cancelled out when ratios are used. The methods of obtaining these data were very cumbersome on the a-c network analyzer when more than one circuit was on the same right of way. Few points were taken and curves were plotted to show the data. This required considerable time both for

the analyzer and for study preparation and curve plotting.

A method has been developed[6] which greatly simplifies and speeds up the calculation. This has been programmed for the digital computer and now calculates 100 positions along a line in from 1 to 2 minutes where more than an hour was required on the analyzer for 8 to 10 positions. Curve plotting is eliminated as the large number of positions calculated makes the printed tabulation as it comes from the computer sufficient.

The method of intermediate position line fault calculations[6] is limited to areas where the mutually coupled lines terminate in a common bus at each end.

There are many cases in which the terminating mutually coupled transmission lines go to a split bus at one end or both ends. A combination of the previously mentioned method and the matrix fault calculation method has been programmed which will calculate for these conditions. This combination method is slower but will produce the required data for a 3- or 4-line mutually coupled system in approximately 30 minutes for 100 positions of fault. These two programs permit rapid calculation of almost all required intermediate point fault calculations on the system, giving the results in a tabulated form. These intermediate positions also are useful in determining currents for communication parallels, points of series capacitor flashover, and currents for expulsion fuse applications.

CIRCUIT BREAKER DUTIES

IN AN EXPANDING POWER SYSTEM with many circuit breakers, it is necessary to review the breaker interrupting duties on the system. We try at the Bonneville Power Administration system to check these duties once a year so that breaker changeouts may be made or anticipated before the breaker is subject to overstress. The breakers are checked for both their 3-phase as well as single-phase-to-ground fault duties. It is important for the ground fault duty that the actual phase current through the breaker be determined instead of the ground current that is normally used for relaying.[7] Rather extensive amounts of calculation are required when a large number of breakers are involved.

A program has been developed for the digital computer to determine the 3-phase and single-phase-to-ground fault duty in terms of phase currents for all bus tie, line, and transformer position breakers. The computer will be programmed to calculate the duties on all high-voltage circuit breakers but to list the duties only on circuit breakers whose duty will exceed 70% (or any desired value) of their symmetrical interrupting duty rating. The basic fault current data will be obtained from previously calculated fault studies.

CONCLUSIONS

THE USE of the digital computer for the solution of several types of power network short circuit problems has proved very practicable.

The average over-all time of solution per fault is faster than required by the a-c network analyzer. Plans are being made to reduce the solution time by a factor of 5 or 6.

Corrections or adding omitted faults to a study are readily accomplished using the computer method where the entire study would have to be reset on the analyzer to obtain the data.

It is believed the accuracy of the results is greater with the computer and small values of negative impedance can be accurately represented.

The actual running of the study may be done with subprofessional help and, at the same time, the a-c network analyzer and engineers required to run the fault study may be released for other uses.

Calculation time of intermediate position faults along a transmission line for fault location work is considerably reduced over network analyzer methods.

REFERENCES

1. High-Voltage Power System Fault Current Asymmetry, M. J. Lantz. AIEE *Transactions*, vol. 75, pt. III, June 1956, pp. 292-97.

2. Power System Fault Current Analysis Including Study of Transient Offset, M. J. Lantz. *Ibid.*, vol. 73, pt. III, Oct. 1954, pp. 1073-78.

3. Digital Short Circuit Solution of Power System Networks Including Mutual Impedance, M. J. Lantz. AIEE paper 57-796, scheduled for publication in AIEE *Power Apparatus and Systems*, 1957.

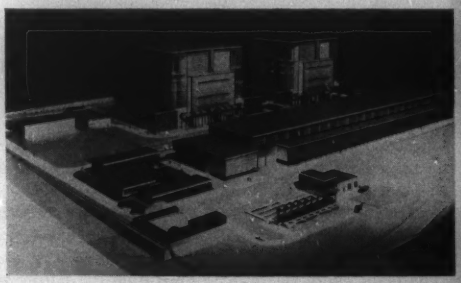
4. The Effect of Mutual Induction Between Parallel Transmission Lines on Current Flow to Ground Faults, M. J. Lantz, J. I. Holbeck. AIEE *Transactions*, vol. 62, 1943, pp. 712-15.

5. Fault Location Experience Using Current Ratio Method, M. J. Lantz. *Proceedings*, American Power Conference, Chicago, Ill., vol. XVIII, 1956, pp. 502-04.

6. Simplified Method for Calculating Intermediate Faults on Mutually Coupled Transmission Lines, M. J. Lantz. AIEE *Transactions*, vol. 75, pt. III, Oct. 1956, pp. 964-67.

7. Analysis of Fault Currents for High Voltage Circuit Breaker Interruption, M. J. Lantz. *Ibid.*, vol. 74, pt. III, Apr. 1955, pp. 41-45.

New British Nuclear Plant



Great Britain recently announced that work will start immediately on a nuclear power station claimed to be the largest in the world. Its output will be 500,000 kw, or over six times as great as that of Calder Hall's Station A, the world's first industrial-scale nuclear power plant, which was opened in October 1956, also in England. Shown is a model of the new plant, to be located at Hinkley Point, Somerset, England.

Insulation Phenomena of Compressed Air

L. D. McCONNELL
ASSOCIATE MEMBER AIEE

Various breakdown phenomena of air insulation have been encountered in the development of an air-insulated air-blast breaker. Methods used in the location, analysis, and correction of the breakdown are described. The use of insulating material in conjunction with high-pressure air is covered briefly.

THE RELATIVELY HIGH insulating properties of compressed gases have been recognized for over a quarter of a century. Over the past 20 years a great deal of experimental data have been published on the dielectric strength of compressed gases.[1] Much of the work done, however, has been of a strict scientific aspect.

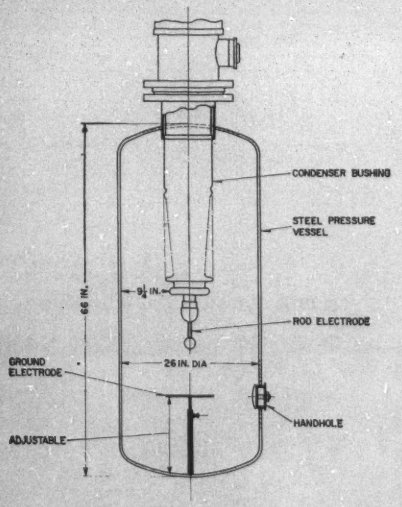


Fig. 1. Section of electrode test tank showing typical electrode positioning.

The main effort has been to determine the nature of the breakdown of high-pressure gases and the mechanisms which play a role in this breakdown. In general, the pressure ranges investigated have been wide, covering the field up to approximately 50 atmospheres. The electrode spacings employed have, however, generally been small; of the order of 1 inch or less. The major part of the data covers direct voltage and 60-cycle breakdown of high-pressure gases. One investigator[2] has presented experimental data on the breakdown of compressed gases up to 200 psi absolute, by 1½x40-microsecond impulse voltages, and with electrode spacings up to 10 centimeters. Part of the work reported here is in extention, particularly on impulse voltage, to available data.

From the theoretical and experimental work, certain fundamentals with respect to the breakdown of high-pressure air have been established. Those of prime consideration in the application of compressed air in a practical system of equipment insulation may be generalized as follows:

1. The breakdown level for a uniform field system does not follow Paschen's law.[1-2] That is, the breakdown value does not vary as a direct product of pressure and electrode spacing. Abnormally low values of breakdown are found in the range of approximately 8 to 10 atmospheres for uniform fields. For nonuniform fields, the critical pressures where irregularities in level are found are at even lower values, of from approximately 5 atmospheres. In the case of the nonuniform field, as the critical pressure is reached, the sparkover occurs at the corona starting point with little prebreakdown current. The breakdown can be found by test to be a positive point-to-plane phenomenon, with sparkover occurring on the positive half cycle of the 60-cycle wave. The resulting irregularities or recessions in breakdown voltage place a premium on proper electrostatic design. A need for generous radii of curvature on apparatus electrodes is introduced.

2. The increase in dielectric strength of air with increasing pressure, relative to the strength at atmospheric pressure, is much greater for uniform than for nonuniform fields. This, as well, points to the need for generous radii on electrodes in a practical design, if the full benefits of high-pressure air as an insulating medium are to be realized.

TEST APPARATUS

THE EXPERIMENTAL DATA presented in this article were obtained in a special steel pressure vessel. A standard 138-kv oil-filled condenser bushing was used to admit the voltage to the live electrode. A cross-section of the tank, indicating electrode configuration and posi-

Full text of conference paper CP57-725, presented at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957, at a session sponsored by the AIEE Switchgear Committee.

L. D. McConnell is with the Canadian Westinghouse Company, Ltd., Hamilton, Ont., Canada.

The author is indebted to co-worker H. H. McKeough for his part in conducting the electrode breakdown tests.

tioning is shown in Fig. 1. Electrode adjustments were made through a hand hole in the tank wall.

The 60-cycle test voltage was supplied from a 350-kv, 350-kva testing transformer. Voltage control was by means of an induction regulator on the transformer primary winding. The impulse voltage was supplied from the lower steps of a 3,250-kv impulse generator. Impulse voltage waveshape was checked and the breakdowns observed by means of a cathode-ray oscillograph connected by a resistance divider. All impulse data presented is for a 1½x40-microsecond wave. Voltage calibration throughout the tests was to accepted standards.[3]

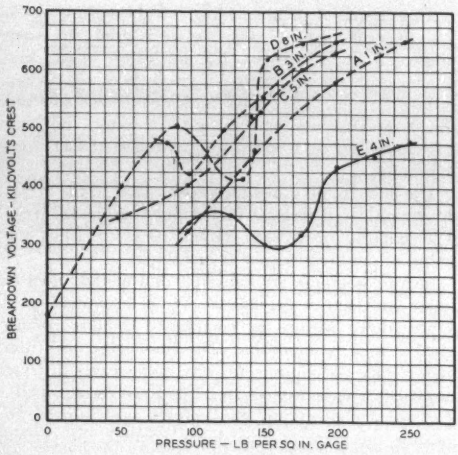


Fig. 2. Pressure curves for 2-inch diameter sphere to 9-inch diameter flat plate. Dashed curves: 1½x40 impulse (rod positive); solid curve: 60-cycle crest.

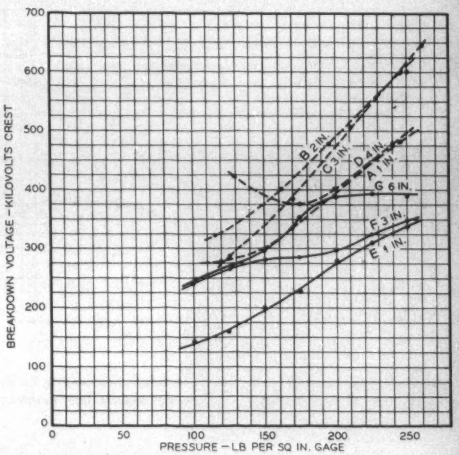


Fig. 3. Breakdown curves for 1-inch rod (hemispherical end) to 9-inch diameter flat plate. Dashed curves: 1½x40 impulse (rod positive); solid curves: 60-cycle crest.

The electrode systems employed were of three types. For each type, the ground electrode consisted of a 9-inch diameter flat steel plate. The live electrodes, connected to the lower end of the condenser bushing, were (1) a 2-inch diameter steel sphere, (2) a 1-inch diameter brass rod with hemispherical end, and (3) a ½-inch diameter brass rod with hemispherical end.

Surface finish on the electrodes was to a 63-microinch standard or better at commencement of the tests. No polishing or electrode conditioning was done during the tests.

The air employed was not purified or filtered. Air dryness varied in the dewpoint range of from 0 degrees F to −20 F at atmospheric pressure. All tests were conducted at ambient room temperatures.

ELECTRODE TEST RESULTS

THE BREAKDOWN VOLTAGE VS PRESSURE curves obtained for these three electrode systems listed, are shown in Figs. 2, 3, and 4. For comparison purposes, the 60-cycle breakdown voltage, in terms of crest value, and the positive wave impulse breakdown are plotted on the one figure, for each electrode system. The test points taken are indicated by dots on the curves, and are at approximately 25-pound pressure increments. The plotted points on the impulse curves are the lowest value obtained in a series of tests. Generally, at least two breakdowns were made at any setting to determine the breakdown level.

From examination of the breakdown curves, it was observed that recessions occur where, throughout at least a small pressure range, the breakdown of a larger gap exhibits a lower breakdown than a small gap. Two prime examples of this may be seen from Fig. 2, for the 2-inch diameter sphere-to-plane configuration:

1. The 8-inch gap on impulse voltage indicates a critical range at 100 to 150 psig, where a recession occurs to a value lower than the corresponding breakdown for a 1-inch gap. The explanation for this type of recession is likely to be the positive-point-to-plane phenomenon mentioned previously. Insufficient test points were taken to assure the exact form or extreme lower limit of the curve. However, the recession and recovery at increased pressure appear to be very sharp.

2. A second example from Fig. 2 is the apparent lower breakdown level for a 5-inch gap over a 3-inch gap, for the full pressure range of 75 to 200 psig. Although both of these curves indicate irregularities, there appears to be no typically sharp critical range for the 5-inch gap. Other examples of this wide pressure range recession are found in Fig. 3 for the 1-inch rod at 4-inch gap, and in Fig. 4 for the ½-inch rod at 3-inch gap.

Inasmuch as these irregularities appear to differ from the sharp recession type, other factors than a critical pressure may enter into their cause. Factors such as moisture vapor content or temperature variations of the air[4] might be considered. Another explanation might be the existence of a critical gap or electrode spacing.

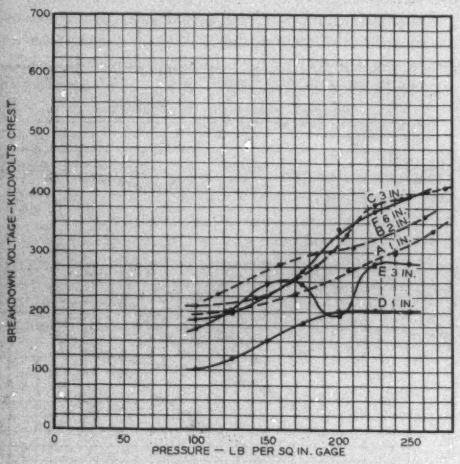


Fig. 4. Breakdown curves for ½-inch rod (hemispherical end) to 9-inch diameter flat plate. Dashed curves: 1½x40 impulse (rod positive); solid curves: 60-cycle crest.

From a practical or application viewpoint, where nonuniform fields are most usually the rule, one thing is apparent. Increasing the gap alone in an electrode system may not result in an increased insulation level, because of irregularities in the insulating level.

A second observation may be made from examination of the three sets of curves. From the point of view of average breakdown, the curves do show the expected definite raising of the breakdown level as the radius of the electrode is increased. The test results indicate, generally, that doubling the radius of the sharp electrode has far greater effect than doubling the electrode gap. For a practical application this further confirms the need for generous radii on electrodes.

A third observation from the test results may be made with regard to the impulse ratio. This ratio, between the breakdown value of the impulse crest over the 60-cycle crest voltage, is not always found to be greater than unity. Values of from 0.92 to 1.75 may be obtained from the curves. From this, it is apparent that the impulse breakdown may be the controlling factor in equipment designed with compressed-air insulation. For example, to meet a 650 BIL rating with a 310-kv 60-cycle test level an impulse ratio of 1.48 is implied, if both impulse and 60-cycle tests are to be met with the same margin of insulation. This ratio is not assured with the electrode systems tested, and might be expected to be less as sphere gap characteristics were approached.

AIR-INSULATED SYSTEM

In the design of air-insulated equipment such as an air-blast circuit breaker[5] it is not always feasible to incorporate ideal electrode form into components whose main functions are mechanical operation or electrical connection. Thus, the use of shields incorporating the desired electrode form to encompass these parts is often necessary.

An example of such shielding is indicated in Fig. 5. This is a photograph taken inside a dead-tank compressed-air circuit breaker. The shields are of cast aluminum with smooth radii on the corners and buffed surface finishes. The forms indicated encompass and shield the sharpness of electrical connectors, mechanical mountings, and bolted joints from electrical stress to ground.

The photograph shows the system raised to the breakdown point to determine the ultimate insulation level. The impulse breakdown visible occurred from the radius at the lower corner of one shield.

Such photographs are indicative of a method used to locate and analyze breakdown. Visual examination of a breakdown within the compressed-air-filled circuit-breaker tank is impossible. The low-energy arc, from high-voltage test equipment, very often leaves little or no evidence in the form of an arc crater at the terminals. The use of photography, thus, proves most valuable in locating the point of breakdown. Further, the permanent record so produced affords data of assistance in analyzing the cause of breakdown. For example, Fig. 5 would indicate that if the breakdown level required increasing, the radius, or spacing, at the lower curvature of the shield would need increasing.

To obtain photographs on a high-voltage test, the camera, located on the tank floor, was focused at any desired portion of the electrode system. The film was briefly exposed with a lamp in the tank to provide illumination for outlining the subject. With the tank darkened, the shutter was then locked open and remained so until after the test was complete.

SOLID–AIR INSULATION IN COMBINATION

An alternative to the use of shields that might be considered is the application of barriers of solid insulation. These play a very effective and prominent part in oil insulated equipment of many types. There are, however, factors of difference between the two systems. The dielectric constant of compressed air is unity, whereas that of insulating oils is approximately 2.2 and of barrier material from approximately 2 to 4. Because of this wide spread in permittivity between the air and solid, as compared with the oil–solid combination, the barrier in series with air assumes a relatively small por-

Fig. 5. Photograph of compressed-air-insulated system showing impulse breakdown originating at shield curvature.

tion of the voltage across the series combination. At the same time, the stress in air is increased due to the addition of material of high dielectric constant.[6] The air–solid system, thus, is placed at a disadvantage in comparison with the oil–solid combination, when fairly uniform fields are considered.

In nonuniform fields, such as the rod-to-plate configuration, the barrier in combination with air does apparently play a part in field-forming, to effect increased breakdown. Several tests were conducted at atmospheric pressure with variations made in barrier positioning. The results agreed closely with data published by Roth.[7] The effectiveness of the barrier was found to be strongly dependent upon positioning between the live and ground electrodes. Most advantageous barrier positioning was found to be at approximately ¼ of the gap distance away from the live electrode. In this range, breakdown level increases of better than 200% over air insulation alone have been recorded. The breakdown with barriers may be either in the form of puncture or creepage around the solid insulation, depending on positioning, size, and form of the barrier.

Other factors require consideration in the design of practical compressed-air-insulated apparatus employing barriers. Support of barrier members, creepage characteristics over supports and barriers, barrier forms and materials, and the insulation level of these, in combination with high-pressure air and various electrodes, require considerable primary investigation. With the very limited amount of published data, at present, the full evaluation of barriers in compressed air cannot be made.

Solid insulation is, however, generally required in compressed-air-insulated apparatus for the support and operation of high-voltage electrodes. This insulation is generally stressed in creepage. The creepage characteristics of solid insulation under compressed air have been reported[4] to be dependent on the insulating material and particularly on the termination at electrode surfaces.

This matter of termination was found in one practical instance to be critical. Fig. 6 indicates a 60-cycle breakdown to ground caused by an improper junction of live part and insulation. Corona from charging current to the insulating member introduced a triggering effect that resulted in air breakdown to ground. This effect is overcome in a redesign with the insulating member carried over the live electrode, in semibarrier form, in such a way that corona does not exist within the test-voltage range.

CONCLUSION

With the present state of knowledge of breakdown phenomena in compressed air, each electrode system in a practical design must be given individual study. Because of relatively large irregularities in insulation level, as a function of pressure and gap, each electrode system must be proved by test if exact levels are to be determined.

Tests and experience indicate that good field form is a far more important factor in determining insulation than spacing of electrodes.

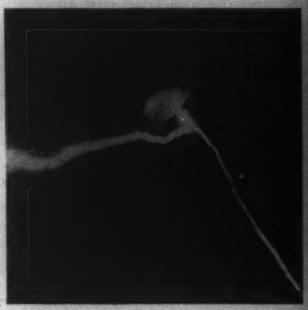


Fig. 6. Photograph showing 60-cycle breakdown originating at junction of electrode and solid insulation.

Either the 60-cycle or impulse-withstand characteristic may be the controlling factor for high-voltage apparatus employing compressed-air insulation.

Further experimental data is required to evaluate the effectiveness of barriers in compressed-air-insulated systems.

Creepage characteristics of solid insulation under compressed air are dependent upon the properties of the material and particularly on the type of termination at electrode surfaces.

REFERENCES

1. Breakdown in Compressed Gases, A. H. Howell. AIEE *Transactions*, vol. 58, 1939, pp. 193-205.

2. High-Pressure Gas as a Dielectric, G. C. Nonken. *Ibid.*, vol. 60, 1941, pp. 1017-20.

3. American Standard for Measurement of Test Voltage in Dielectric Tests. AIEE *Standard No. 4* (American Standard C68.1), 1953.

4. Dielectric Materials and Applications (book), A. R. Von Hipple. The Technology Press, Massachusetts Institute of Technology, Cambridge, Mass., and John Wiley & Sons, Inc., New York, N. Y., 1954, pp. 152-54.

5. A New Canadian Compressed-Air Circuit Breaker, C. C. Smith, D. H. McKeough. AIEE *Transactions*, vol. 75, pt. III, Aug. 1956, pp. 713-18 (*Electrical Engineering*, vol. 75, no. 5, May 1956, pp. 446-50).

6. Dielectric Phenomena in High Voltage Engineering (book), F. W. Peek, Jr. McGraw-Hill Book Company, Inc., New York, N. Y., 1929, pp. 31-34, 312-15.

7. Hochspannungstechnik (book) Arnold Roth. Springer-Verlag, Vienna, Austria, 1950, sec. 52: Schirme in Luft, pp. 224-29.

Product Quality Assurance

I. O. KARRAKER

FOR THE MANY YEARS that statistical quality control procedures have been used by the Western Electric Company in its manufacturing processes, an audit has also been made which is, in reality, a statistical evaluation of the completed telephone product being shipped from the manufacturing plants. This audit is termed "quality assurance" in the Western Electric Company. Data thus gathered are used by the Bell Laboratories in putting together a picture of quality which serves to provide the customers (operating telephone companies) with evidence that the product they receive is up to the quality standard they require. On this basis, they find, in the main, that it is possible to eliminate acceptance inspection and the associated cost on products being delivered to them by the Western Electric Company. In addition, the quality audit furnishes Western Electric management a continuing picture of manufacturing quality and has been an important factor in achieving balance between quality of product and cost of manufacturing.

Although there are many types of telephone products, simple and complex, small and large, the treatment of a sample is the same, regardless of the item; namely, to determine whether the product conforms to the engineering requirements and standards of workmanship which have been established by the Bell Telephone Laboratories. Evaluation of quality assurance sampling results is on a monthly basis, although samples must be chosen throughout the month in order to be random and representative of output. Size of monthly sample varies with output and may be different for various product classes.

When a sample is selected, it is thoroughly inspected by quality assurance personnel to its requirements as determined by drawings, specifications, and other sources. Defects discovered are assessed in demerits based on a fourfold classification which is defined in terms of seriousness:

Class A defects (100 demerits). These are very serious from the standpoint of service in the field, and are difficult to locate or correct.

Class B defects (50 demerits). These are serious, although, in general, they can readily be corrected in service when found.

Class C defects (10 demerits). These defects are moderately serious. They do not, in general, cause immediate operating failure, but may result in increased maintenance or decreased life.

Class D defects (1 demerit). Class D defects are not serious and do not affect operation, maintenance, or service life.

To provide a yardstick against which the quality of the sample, as measured in demerits, can be compared, Western Electric has developed the "standard quality level," which may be defined as the expected average value of demerits per unit. This average demerit value is determined by a check of the records of quality assurance inspection during a base period in which the product in question has delivered normally satisfactory service. Deviation from the standard is considered significant when it is in excess of two sigma, where sigma is determined from sample size and "standard quality variance" (measure in demerits per unit values to be expected of samples from product having quality at the standard quality level).

Western Electric quality assurance issues two reports. One, quarterly, shows a chart for every product which is checked and rated by the quality assurance organization at all manufacturing locations regardless of whether the quality may be normal or otherwise. This publication provides an historical record of the status of each product for a three-year period and is particularly helpful in calling to the attention of supervision any quality trends which may manifest themselves over a period of time. The second report is issued monthly and contains charts only on those products which quality assurance inspection has shown to be below normal for the month. It also contains general indexes for the over-all performance of each plant and of the record of loose soldered connections which are found at each plant. This report is circulated at high management levels, and appearance of a chart on some product in this publication is generally the signal for drastic corrective action on the part of the people responsible for its manufacture.

In order that the quality assurance organization may be free from pressures for production, it has been set up under engineering rather than production supervision. At each manufacturing plant, the quality assurance resident head is not in any way responsible to the production supervision at that location. The entire organization is headed by a superintendent of quality assurance, located at company headquarters in New York, N.Y., who reports eventually to the vice-president and chief engineer.

Personnel includes engineers, quality checkers, statistical clerks, secretaries, and other clerical help. Engineers design and sometimes build test equipment. They investigate and answer complaints, analyze historical data, and develop standard quality levels. Quality checkers perform actual inspections, using handbook instructions, drawings, and specifications. Statistical clerks, each month, calculate actual quality rates using standard formulas and preliminary reports prepared by quality checkers.

Digest of paper 57-808, "Quality Assurance—An Essential Part of the Western Electric Manufacturing Process," recommended by the AIEE Communication Switching Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Scheduled for publication in AIEE *Communication and Electronics*, 1957.

I. O. Karraker is with the Western Electric Company, Omaha, Neb.

Internal Corona Spaces in Cables

D. W. KITCHIN
ASSOCIATE MEMBER AIEE

O. S. PRATT

IN THE DEVELOPMENT of high-voltage cables insulated with thermoplastics or rubber, it is necessary to measure the corona onset voltage. The manometric method detects internal corona by the decrease in air pressure caused by absorption of corona-activated oxygen. The rate of pressure drop increases rapidly with voltage. By connecting a capillary oil manometer to the sample, this pressure drop can be measured. In this study, all voltages are 60 cycles rms.

Fig. 1 shows corona absorption in a high-voltage polyethylene cable without strand shielding, before and after bending. This method has been used up to 120 kv and, in principle, there appears to be no upper voltage limit.

A more refined technique is to connect two identical samples symmetrically to opposite legs of a U-tube manometer and stress one of them. Disturbing effects of diffusion and of fluctuations of ambient temperature and pressure cancel out. Thus, it is possible to determine the corona onset voltage with considerable precision. This is illustrated in Fig. 2 for 15-kv polyethylene cable, with no strand shielding. The corona onset was lowered by bending from 36 kv to 17 kv.

Autographic mapping can be used with cable having no strand shielding and nontinned stranded copper conductor. A 10% silver cyanide solution is drawn through the conductor by vacuum methods. Copper surfaces accessible to liquid receive a coating of silver. Silvered areas map on the outside of the conductor the projections of adajcent corona spaces. This test requires only a 2-foot sample. It can provide conclusive evidence of the existence of corona spaces.

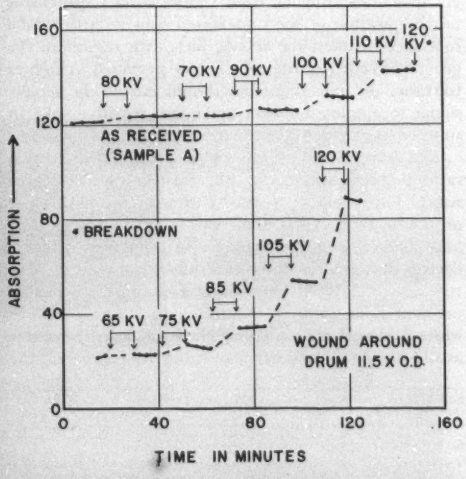


Fig. 1. Corona absorption in high-voltage polyethylene cable before and after bending.

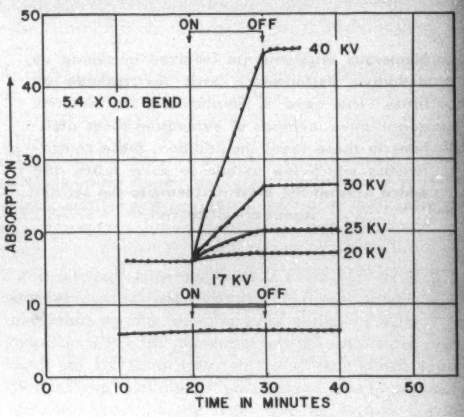


Fig. 2. Results obtained with balanced-sample method on 15-kv polyethylene cable after bending.

Although corona absorption has been demonstrated with butyl rubber, polyvinyl chloride, silicone, Teflon, and even glass, the manometric method gives the most satisfactory results with polyethylene cables. This is because polyethylene has negligible dielectric heating. In polyvinyl chloride cable, the dielectric heating increases the air pressure inside, thus tending to mask the absorption, or pressure decrease. The net absorption can be read after eventual cooling on removal of stress, but it is difficult to determine the corona level precisely. With such insulation, the silver mapping method is preferable as a criterion of the presence of internal corona spaces.

These methods are not offered as routine factory tests, but rather in the hope that they may contribute to making the studies of internal corona more direct and conclusive.

Digest of paper 57-711, recommended by the AIEE Dielectrics Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1957.

D. W. Kitchin and O. S. Pratt are with the Simplex Wire & Cable Company, Cambridge, Mass.

Color and Monochrome Cathode-Ray Tube Performance Tests

C. F. OTIS

Numerous problems are involved in setting up definitive performance tests for cathode-ray tubes. The need is emphasized for absolute quantitative methods of evaluating focus problems in these tubes. In addition, those characteristics which are unique to color tubes and which present the most problems to the set designer are discussed.

THE ENGINEER in a television manufacturer's plant who is responsible for cathode-ray tube (CRT) testing faces peculiar and, at times, baffling situations. On the one hand, the CRT manufacturer insists that since his tubes meet all the Joint Electron Tube Engineering Committee specifications plus a few of his own, there should be no question about acceptance of the tubes in unlimited quantities. Exerting pressure from the opposite direction is the set engineer, who, confident of his own ability, is quick to blame any undesirable characteristics of the complete set on the cathode-ray tube. Squeezed between these two conflicting forces the CRT engineer must first determine the type of problem, if one exists, and second, arrive at a solution which will result in the best possible picture quality for the completed set. Finally, this solution must be such that a sufficient number of tubes can be supplied by the CRT manufacturer to meet production needs at a competitive price.

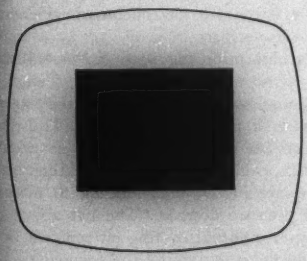


Fig. 1. Contrast measurement chart.

MONOCHROME TUBE TESTING

INASMUCH AS the most experience has been gained with monochrome tubes, the approach to the testing problem will start with this type of tube. Sufficient shadow clearance is a constant problem to the set engineer. Sufficient clearance would mean that in all parts of the country and under all conditions of station blanking, with the linearity available in the set, the video information can be centered on the tube face without the inner contours of the glass bulb masking off a portion of the picture. The steps previously taken by CRT manufacturers to insure sufficient clearance have not been adequate. It is standard practice in tube plants to check shadow clearance by means of special yokes which are constructed in such a manner as to slide back on the tube neck a controlled distance. Tubes producing shadow with these yokes are labeled rejects. However, no attempt is made to center the raster on the tube face at the time this test is made. Such a test as this does insure that the glassware is correct or at least the inner contours meet a prescribed minimum dimension. However, no check is made on the gun alignment within the tube. If, when the raster is centered on the tube face, the undeflected beam does not pass through the center of the tube, neck shadow can be present even though the glassware is within specifications. With the advent of the non-ion trap tube, the situation has improved. For one reason, more consistent shadow measurements can be made. Positioning of the beam bender was one of the main deterrents of repeatable shadow determinations. Second, the CRT manufacturers are now willing to place a more strict requirement on the position of the undeflected spot relative to the tube face. A tolerance of $\pm\frac{3}{8}$ inch with respect to the geometric center of the tube is now proposed. A tighter tolerance on gun alignment should enable the set designer to employ a longer and more sensitive yoke in spite of less shadow clearance.

The new 110-degree tubes have presented a contrast ratio problem which did not exist in the 90-degree tubes. This problem is associated with the dark areas of the picture rather than the bright portion. The phosphor in these dark areas is being activated by reflected electrons resulting in diluted black areas. The technique employed for making a contrast ratio measurement is to use a special slide which forms a plain white field with a rectangular black patch in the center as shown in Fig. 1. When two tubes are compared, the

Full text of conference paper CP57-1007, presented at the AIEE Fall General Meeting, Chicago, Ill., Oct. 7-11, 1957, at a session sponsored by the AIEE Television and Aural Broadcasting Systems Committee.

C. F. Otis is with the Philco Corporation, Philadelphia, Pa.

The author wishes to acknowledge the assistance of Henry Vasilevskis, who directed the design and construction of the test rack and proposed as well as constructed the dilution meter. Harry Schulze, a student engineer from Drexel Institute of Technology, made several valuable suggestions and assisted in the tube testing.

brightness is adjusted to produce the same light-meter reading in the white area for both tubes and the same raster size. With a sensitive multiplier tube, the brightness in the dark areas are read. The tube with the higher reading will have the poorer contrast ratio.

Initial tests on cathode-ray tubes should never be made in television receivers. Unlimited variations can exist between so-called "identical sets." This problem of duplication can be avoided by inserting, in turn, the tubes to be tested into a single chassis. This is a laborious method and eliminates the possibility of employing a reference or standard tube for comparison. The conventional single-position test racks shown in Fig. 2 and used by CRT manufacturers for production testing of G_1 cutoff, light output, and gas ratio, have likewise proved inadequate for the more subtle tube characteristics such as focus quality. As in the case of the single-chassis technique, this type of rack suffers from the inability to make comparison measurements.

At the Philco Corporation, a 6-position test rack has been constructed to circumvent these deficiencies. Mounted on casters, it is completely mobile. Each tube position is capable of accepting any size tube from 8½ to 24 inches (diagonal), as shown in Fig. 3. To insure that each position receives an identical video signal, there is a single video amplifier feeding individual output stages at each position. The separate output stages permit individual contrast controls. Because the plate load resistances of these output stages are only 1,200 ohms, a bandwidth of 5 megacycles is easily obtained. A switch is available to add shunting circuits which will drop the bandwidth to the more conventional 3.0 megacycles of present-day receivers. Because the Philco signal center is capable of sending to the test position, via coaxial cable, practically any type of video signal, this is usually the only type of signal-handling amplifier required. By eliminating the tuner and i-f amplifiers, all questions of correct tuning and amplifier alignment have been avoided. However, to satisfy set engineers who are accustomed to observing station r-f signals, a tuner and i-f amplifier have been incorporated into the rack. When a switch is thrown, the output of the video detector is fed into the common video amplifier. For 1½ volts peak-to-peak at the second detector, 150 volts is obtained at the plate of the output tube when a monoscope test chart is used. Approximately 25% of this output voltage is synchronizing pulses. This signal can be either positive or negative for cathode or grid drive to the CRT.

At each position, there are individual brightness, contrast, and electrostatic focus controls. The average cathode current in each tube can be read by means of a multiposition switch on one meter while a second meter records the focus voltage. The first meter, when switched into a clamping diode, indicates when the CRT is driven to zero bias, a convenient device in evaluating the performance of low-screen-voltage tubes. The anode voltages are supplied by two commercial power units, one supplying voltage to the upper three positions of the rack and the second unit feeding the lower three tubes. Similarly, two separate screen supplies feed the upper and lower positions. The anode voltages are read on the power units and the screen voltages are shown on the second rack meter.

New types of cathode-ray tubes are being brought out at such a rapid rate that it is difficult to make modifications in the rack fast enough to keep up with the new tubes. With the two screen sources and means of cathode driving the tubes, it is possible to compare a low-screen-voltage tube with the conventional *17AVP4* and *21BTP4* tubes. Fortunately, the new 110-degree tubes with their special yokes will fit mechanically in the rack and, with adapter cables for the base connections, they can be checked with a minimum of effort. Our major objection at the present is that the rack will not test color tubes, and there is no way of knowing which type of color tube the rack should be designed to accept.

Fig. 2. Conventional cathode-ray tube test rack.

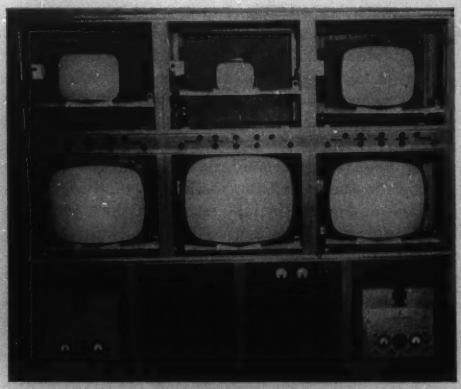


Fig. 3. Multiposition rack with tubes.

Fig. 4. Resolution charts.

Having a convenient rack available, it is now time to put it to use. The most difficult characteristic of a cathode-ray tube to evaluate, either quantitatively or qualitatively, is focus quality, or the ability to resolve fine detail. There are several reasons for this difficulty. If focus quality is to be determined by an observer comparing several tubes while viewing television pictures, he will be influenced by other CRT characteristics. The colors of the tubes under test, the contrast ratio obtainable from the tubes, the depth of focus, the focus voltage applied, and the zero-bias emission all will influence his judgment one way or the other. Second, the evaluation of focus quality very easily can slip into the realm of personal preference, particularly when only television scenes are used in the tests. Third, there is no single test or single test pattern which can be used to furnish either a quantitative or qualitative analysis of the focus quality. Resolution charts such as Fig. 4 are helpful, but because of their low peak-to-average brightness ratio furnish little information about the tube at high beam currents (750 to 1,000 microamperes).

In this section are described briefly some of the test signals used at Philco with the particular focusing characteristic emphasized by means of the signal. The resolution chart shown in Fig. 4 can be used as a quantitative measurement of resolution. In addition, the depth of focus can be measured for electrostatic tubes in terms of the focus voltage required at the center of the pattern as compared to some point at a specified distance away from the center. Obviously yokes with known astigmatism characteristics should be used. Slides, rather than station scenes, are convenient for comparative measurements of focus quality, as they are always available and can be maintained for any length of time for leisurely inspection. Fig. 5, from the National Television System Committee color slides, with its fine detail at several brightness levels has proved to be a valuable calibrating instrument for monochrome tubes. This has proved to be true for several slides originally constructed for the tri-gun color tube. The familiar inverted cross-hatch pattern shown in Fig. 6 was originally intended for convergence work. However, if the video drive is adjusted so that the dark portions are at zero beam current and the white lines set for equal brightness on the tubes in the test rack, the width of the white lines is a measure of spot size. By increasing the video drive, measurements at various peak beam currents can be made without drawing excessive current from the anode supply. The slide in Fig. 7 was also intended for convergence work but has proved a valuable aid for observing any "halo" effects in the CRT, particularly at high beam currents. This "halo" effect is characterized by a semi-illuminated area existing around each bright spot on the screen, even though the focus voltage has been adjusted for an optimum value. The problem was first encountered with the tubes requiring no ion traps and appears in the positive grid region of the CRT. With its numerous black-and-white transitions and high peak-to-average brightness, this slide is a convenient tool for this type of investigation.

The spot generator or pulsing unit which produces a single white dot in the center of the CRT face is still a necessary instrument in any focus quality evaluation. Provisions should be made for increasing the size of the driving pulse to enable the grid of the CRT to be driven into the positive region for checking the previously mentioned "halo" effect. A more accurate observation of this effect can be obtained with the spot generator than with any of the slides. A clamping diode, which measures the height of the applied pulse, is necessary in order that the peak beam current may be determined. The sizes and shapes of the spots are read directly off the face of the CRT.

With the exception of the slide shown in Fig. 5, the techniques described have avoided the pitfalls associated with judging focus quality by means of station television pictures. With the predominance of black areas in the slides described, picture tube color has little effect. If the convergence patterns shown in Figs. 6 and 7 are used and the contrast controls in the rack are adjusted to make black at zero beam current, and if the

Fig. 5. Jewelry slide.

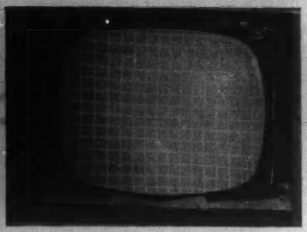


Fig. 6. Inverted cross-hatch pattern.

average beam currents of the tubes under test are made equal with the brightness controls, the peak currents also will be approximately the same. The effect of the control-grid cut-off voltage and zero-bias emission need no longer be considered. By means of the clamping diode in the dot generator, all tubes are set directly at the same peak currents for the tests. Because the test patterns have high peak-to-average brightness ratios, factors which contribute to a poor contrast ratio such as stray emission and reflected electrons have negligible effect on the test results. If the evaluation is restricted to the center portion of the CRT screen, the depths of focus and yoke astigmatism problems may be avoided.

Two limitations to our testing techniques still remain. The first limitation involves the applied focus voltage. Each position in the rack has its own focus control which can vary the voltage from −750 to +750 volts. When the tests are made, should the focus voltage be initially set up on a monoscope pattern at some prescribed average beam current and then remain fixed for the remainder of the tests? With electrostatic tubes, five different observers would choose five different focus voltages varying by 200 volts. In a television receiver, there are usually only two or three different focus voltages available. It would seem more logical from the set designer's viewpoint to select one of these voltages and maintain it throughout the tests. Better results can be obtained from the tube if the focus voltage is adjusted for each type of signal. Obviously, the CRT manufacturer would like to take advantage of this flexibility. The focus-voltage problem becomes even more important when spot-size measurements on an electrostatic tube are made with a spot generator. As the focus voltage is varied from +750 toward −750 the spot grows smaller until a halo appears around the spot. As the focus voltage continues in a negative direction, the halo increases in size and the bright spot in the center becomes smaller. At what voltage should the spot size be measured? Some people use the focus voltage obtained from a test chart and measure the size of the bright spot in the halo. Other engineers adjust the focus voltage until the halo just disappears and make their measurements at this voltage. The present technique at Philco is to employ the latter method of determining focus voltage when using the dot generator and to adjust the voltage for optimum on each slide.

If the 6-position test rack and the comparison method between a standard tube and several tubes under test are used, the results are still subject to the personal whims of the observer. Although we have succeeded in removing a number of errors contributed by human frailties, our decisions with respect to CRT quality are based mainly on qualitative rather than quantitative measurements. One of the main purposes of this article is to present the need for absolute quantitative methods of evaluating focus quality in cathode-ray tubes. It is hoped that the techniques described here will encourage other engineers to apply their efforts in this direction.

COLOR TUBE TESTING

This discussion will be confined to those characteristics which are unique to color tubes and which present the most problems to the set designer. Inasmuch as our experience has been primarily with the tri-gun construction, the information presented will be restricted to this type of tube. The greatest problem of this tube is presenting an acceptable monochrome picture. The

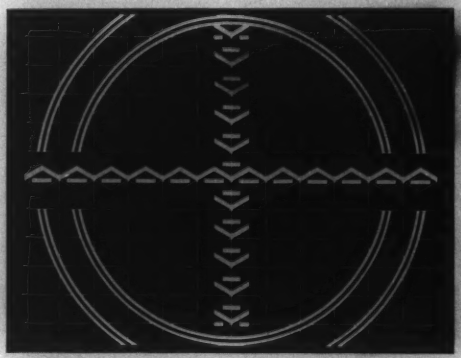


Fig. 7. Convergence chart.

tube characteristic which is one of the main factors in this problem is called color purity. Two types of purity are commonly mentioned, flat field purity, which defines the uniformity of color when only one gun is applied at a time, and white field purity, which defines the uniformity of color when all three guns are applied simultaneously. Lack of uniformity may be caused by incorrectly positioned phosphor dots during the printing process, effects of the earth's field, stray fields set up from the set or induced into the tube itself, or incorrect positioning of the external devices suspended on the tube, such as the color purity magnet, yokes, and field neutralizing devices. In general, it is more difficult to obtain a uniform white field than a flat field, since the white field is the sum of the three flat fields. When viewed in a microscope, a discoloration in a red flat

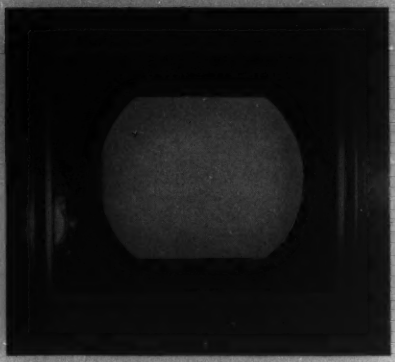


Fig. 8. White purity slide.

field appears when the electrons from the red gun fail to land on the red phosphor dots and overlap onto green or blue phosphors.

Cathode-ray tube manufacturers in their testing equipment have taken elaborate precautions to isolate the tube from all external effects which might tend to make their tube appear poorer than the effects caused by their own errors. Tubes are tested in a rack completely enclosed with mu-metal to produce a field-free space. A controlled field, simulating the vertical component of the earth's field, is introduced by loops of wire placed at the top and bottom of the tube enclosure. Before being tested, the tubes are subjected to a neutralizing field by a "degaussing coil," a loop of wires approximately 20 inches in diameter which is waved around the tube. This procedure removes the effect of any existing field within the tube. Elaborate mechanical controls permit accurate adjustment of the yoke and color purity magnet. To correct for the component of the earth's field entering the front face of the tube and any errors from printing or deformation of the shadow mask, six to eight adjustable magnets positioned on a band around the tube may be adjusted for optimum purity.

Now, the basic problem is faced. What is acceptable color purity? How shall it be defined? There have been a variety of attempts, none of them completely satisfactory. In one method, the tube face is divided into zones, usually concentric circles, and a certain percentage of the zone's area is permitted for impurities, the percentage increasing the greater the distance of the zone from the center of the tube. Measuring the area of the impurity is the problem with this method. Slides showing acceptable amounts of impurity were distributed by one manufacturer. These would show the impurities in particular locations and in particular colors. When applying this slide information to another tube with different impurity locations and color, it is difficult to judge acceptability. Another manufacturer, concentrating on white uniformity, employed a painting instead of a slide, as shown in Fig. 8.

The set designer is interested not only in whether the red beam falls on the red phosphor dot, but also in how well-centered the beam is on the correct phosphor. Conditions in a set are never as controlled as in the CRT manufacturer's test rack, especially with respect to stray fields. In addition, it can be expected that the set will be rotated from its original position where the rim magnets were adjusted. This will alter the earth's field, and some motion of the beam relative to the phosphor dot can be expected. With time and patience, an individual can make a plot of the beam position relative to the correct phosphor dot over the complete tube face with the aid of a microscope. However, this task becomes laborious if a large number of tubes must be tested.

Our present technique is to pretest all tubes in factory test stands, as shown in Fig. 9, before placing the tubes in sets. These stands have no magnetic shielding, thus stimulating receiver conditions. The tubes are adjusted for optimum color purity facing a given direction and are checked for flat field purity with each of the three colors, as well as a white field. If there is difficulty in obtaining purity, the rack can be rotated to check how well-centered the beam is on the correct phosphor. The zoning method previously described determines the acceptability and we depend on the experience of the operator for uniformity. As is true with most acceptance specifications, there are no arguments about the very bad and very good tubes, but the borderline cases may produce some stimulating discussions with CRT suppliers.

General observers usually are not as critical of the tri-gun tube when it is operating with a color signal. This is partially because they are amazed that color is being produced and, second, because they have no previous standard of performance as is the case with

Fig. 9. Production test stand.

monochrome pictures on a color tube. In general, the tri-gun reproduces color quite well when properly adjusted. In our limited production experience, we did experience an interesting chromaticity problem. On a flat field, with only the red gun in operation, some tubes instead of producing a red color actually produced a magenta hue. When the screen was examined with a microscope not only were the red phosphor dots illuminated but also the green and blue dots. However, there was no purity error as the primary electron beam was landing on only the red phosphor. The green and blue phosphor dots were being excited by reflected electrons. The reflection appears to be occurring in the holes of the mask as the diluted red color existed over the entire face of the tube. To check this characteristic, which for a lack of a better name has been called dilution, a special meter was constructed. This meter, shown in Fig. 10, consists of a sensitive photomultiplier tube and meter in addition to a filter holder which enables standard Kodak filters to be inserted in front of the multiplier tube. With only the red gun operating, a reading is first taken with two cyan filters plus a red transmission filter in front of the meter. A second reading is then taken with only a blue transmission filter, and a third reading with the blue filter replaced by a green transmission filter. The purpose of the cyan filters is to keep all three readings at about the same range on the meters. With a reading of 100 for the cyan and red filters the blue and green filter readings should not exceed a prescribed value. The main problem with such meters is to obtain reliable calibration from one meter to another, inasmuch as no two multiplier tubes have similar color responses. Once calibrated, the meters will maintain this calibration over long periods of time. The photomultiplier used is an RCA *6217* with *S-10* spectral response. The slides are red filter, Kodak no. *29*; blue filter, Kodak no. *47B*; green filter, Kodak no. *61*; and the cyan filter, Kodak no. *CC-50C*.

The slide shown in Fig. 7 is a special slide developed by Henry Vasilevskis of the Philco laboratory to simplify the convergence procedure and has been appropriately termed the "crow's foot" pattern. In addition to the familiar crosshatch lines and circle, which are necessary for adjusting linearity and scan width, there are series of little V's along both the vertical and horizontal axes of the chart. Enclosed within the arms of each V is a rectangle with its largest dimension parallel to the horizontal axis. The right-hand arm of each V makes an angle of 30 degrees with respect to the horizontal and, hence, is parallel to the motion of the red beam when either static or dynamic waveshapes are applied to the red convergence pole piece. The left-hand arm of the V is at 150 degrees to the horizontal and parallel to the motion of the green gun under the influence of the converging fields.

Inasmuch as the arms of the V are constructed with these particular angles, convergence errors of the red gun will appear only along the side of the left-hand arm of the V, the motion of the red beam being at an angle of 120 degrees to this side. Similarly, convergence errors

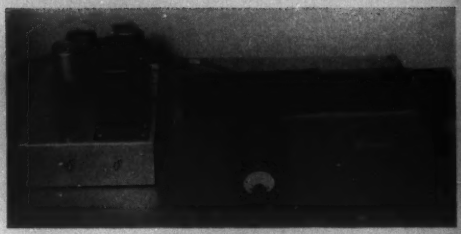


Fig. 10. Dilution meter.

of the green beam appear only along the right-hand arm. The rectangles are used to converge the blue beam upon the converged red and green beams.

The advantage of this chart over the inverted cross hatch lies in the fact that by looking at the misconverged pattern, the operator knows which beam to move and how much to move it. No longer is it necessary to work back and forth between the green and red controls.

A variety of other tests must be applied to the tube to insure acceptable performance in a completed set. However, the majority of them are routine measurements made on all types of cathode-ray tubes or are tests which have been described in other papers.

CONCLUSION

THE EXPERIENCE gained from testing cathode-ray tubes has led to several conclusions which are listed below:

1. An acceptance test should be as simple as possible. The more complicated the test, the more complex become the specifications and their interpretation.
2. The test should be quantitative, if possible. When the results can be measured by a meter instead of an observer's opinion, very little controversy arises.
3. The test should be conducted in a controlled environment. Unknown components and circuits in the measuring equipment which might add more variables should be avoided.
4. Comparative measurements, at present, are the most sensitive means of observing the subtle differences in monochrome tubes.

The test rack technique described in the monochrome section of this article meets the requirements of the conclusions listed. Reproducible slides presented simultaneously on a number of cathode-ray tubes are simple and concise methods of demonstrating tube limitations to a CRT manufacturer. With such a rack, the testing environment is flexible and yet reliable, inspiring confidence in the test results. Unfortunately, judging CRT focus quality is still more of an art than a science, depending primarily on comparative evaluation. The test rack, with its six duplicate testing positions, is ideally suited for such tests.

INSTITUTE ACTIVITIES

A Message to the Individual Section Member on "Membership Month"

"EVERY MEMBER GET A MEMBER" will be the watchwords of AIEE "Membership Month" this November. This is the time toward which the year-round membership activities aim—the time when a program becomes an intensified effort. Each member is strongly urged to recruit *at least one* new member during November. An important part of this general goal is the drive to gain the membership of those engaged in electrical engineering education in the nation's colleges and universities. The Section Membership Committees will spearhead the drive but the co-operation of each individual is vital to make the month a success.

It is suggested by H. R. Heckendorn, national membership chairman, that members review the AIEE Constitution to familiarize themselves with the nature, objectives, and benefits of the Institute before approaching prospective members. Members may contact their Section Membership Committee for reference material concerning the mechanics, processes, and requirements of membership and for hints on how to approach, interview, and interest prospective members.

Many Section Membership Committees will be planning special projects for November and it is hoped that all members will actively participate in them. A number of these projects will take the form of dinners, special meetings, and technical programs to which membership prospects will be invited. At these gatherings, it is felt that one of the most important benefits of AIEE—fellowship—should be at work. And, of course, the spirit of fellowship emanates from the genuine interest of the individual member—in his Society, in his Section, and in the prospective member.

The Institute, to remain a vital organization, must be a continually growing one, receiving "new blood." AIEE offers the electrical engineer many benefits. If he is contacted "at the grass roots" level by the individual Section member, he will be more inclined to investigate the possibilities offered to him by Institute membership. If he has had an inclination to join, but has been hesitant to initiate action, a visit by a friendly and well-informed member is very likely to induce him to carry out his intentions.

Personal contact, then, is the principal means for carrying out the membership program. It is hoped that each individual member will contact as many prospects as possible.

Richland Section Serves as Host to 1957 Pacific General Meeting of AIEE

THE RICHLAND (WASH.) SECTION of AIEE was host to over 600 members and students at the AIEE Pacific General Meeting, held at the Pasco Senior High School, Pasco, Wash., August 28-30, 1957. The meeting was sponsored by three Districts of the Institute—the North Central, the Pacific, and the Northwest.

In addition to the general session, there were 19 technical sessions covering various subjects of interest to electrical engineers, including power generation, nucleonics safety, industrial power systems, substations, radio communications, flight test instrumentation, magnetic amplifiers, human engineering, television and aural broadcasting systems, and many others.

Inspection trips were made to the McNary Dam and Powerhouse on the Columbia River, the Ice Harbor Dam construction, Phillips Pacific Chemical Company plant, and the Midway Substation and Hanford Works area.

A stimulating and enjoyable social program was provided by the Entertainment and Ladies' Committees. The ladies' program featured a brunch at the Desert Inn in Richland on Wednesday, a buffet supper Wednesday evening at the Kennewick Country Club, and a luncheon on Thursday at the Officers Club in North Richland.

On Thursday evening, the members, their families, and guests attended a barbecue at Sacajawea State Park. The entertainment included music by the Snake River Cowboys and water sports demonstrations by the Tri-Cities Water Ski Club.

Present at the barbecue and at several other meeting functions was J. H. Siegfried (AM '03, M '19), one of the oldest Institute members, and resident of Kennewick for the past 35 years, who has had a long and interesting career in the field of electrical engineering. He was born in White Haven, Pa., in 1877, and was graduated from Pennsylvania State College in 1900. His first experience in the industry was with the Cincinnati (Ohio) Edison Company as a construction engineer. Two years later he moved to New York City for a stint with the New York Edison Company, following which he was employed by the Union Electric Light and Power Company, St. Louis, Mo., for nearly four years, where he was in charge of electrical construction. He then worked for a short time for Westinghouse Electric and Manufacturing Company in Pittsburgh, Pa., as an erecting engineer. In 1908, he moved westward to Helena, Mont., where for four years he was general foreman of operations with United Missouri River Power. During the years he was moving around, he was gaining a wide range of experience and became acquainted with many men now recognized as the pioneers of the electric utility industry. Incidentally, he holds membership card No. 968, one of the earliest held by any current member.

In 1912, Mr. Siegfried moved to Kennewick, Wash., where he began a long and distinguished career with the Pacific Power and Light Company. He started out as superintendent of transmission and generation, and subsequently was named superintendent of power, a position he

held until his retirement in 1948. In this latter capacity, he was in charge of operations in the Yakima Valley and the Walla Walla area, and later had responsibility for the Deschutes area and power output at Astoria, Oreg. Throughout his years in the region, he also found time for participation and leadership in civic activities of his home community. His professional activities have included membership in the Northwest Electric Light and Power Association and the American Association for the Advancement of Science.

General Session

The general session, held Wednesday morning, August 28, was called to order by O. W. Hurd, chairman of the Pacific General Meeting Committee. The invocation was presented by Rev. P. F. Nance of the First Christian Church, Pasco.

Brief welcoming addresses were presented by Mayor B. B. Smith of Kennewick, Wash., and H. A. Carlberg, chairman of the Richland Section.

M. M. Ewell, vice-president, District No. 9, then introduced AIEE President W. J. Barrett. President Barrett discussed the AIEE position on the organization of the engineering profession as a whole, as covered in the Board of Directors Meeting at the Summer and Pacific General Meeting, San Francisco, Calif., in June 1956, and reported in a letter by Past President M. S. Coover appearing on page 516 of the June 1957 issue of *Electrical Engineering*. He stressed that the policy is not a proposal for the Institute to disassociate itself from any of its present activities. Rather, it is concerned with those organizations, such as the Engineers Joint Council (EJC), Engineers' Council for Professional Development (ECPD), and National Society of Professional Engineers (NSPE), which deal with problems of the entire engineering profession. It is felt that because there is a multiplicity of these agencies, there has been an overlapping in certain areas, with competition and conflicts resulting in many cases.

The purpose of the policy set forth at San Francisco is to clarify the AIEE position on what these agencies should be doing. Its effect would be most important in defining and limiting the activities carried out by these groups. EJC should handle those matters which are primarily technical in nature, but are too broad in scope to be handled by any one of the individual societies; ECPD, the fields of technical education and the development of young engineers; and NSPE, the professional aspects, including economics, employment, ethics, and contacts with Government regarding legislation affecting engineers.

President Barrett cited the United Engineering Trustees, Inc., as a good example of how an organization can function effectively if its purpose and limits are clearly defined at the outset.

In closing, he discussed the acquisition of the new site for the United Engineering Center in New York City, and showed a color slide of the vicinity in which the building will be located.

An address, "Outstanding Problems in the Atomic Energy Field," was presented by F. K. McCune, vice-president and general manager, Atomic Products Division, General Electric Company. He stated that these problems could be classified into three mutually interdependent categories: technical, political, and economic. He went on to say that the United States has a tremendous supply of relatively inexpensive chemical fuel and the most advanced technology in power generation from these sources of any nation in the world. It will not be an easy task to make electricity from nuclear energy at a cost competitive with chemical fuels in the United States, but he feels confident that this goal will be achieved.

In closing, Mr. McCune stated, "the solution of our technical problems will, in the end, solve our political and economic problems, and in this fact lie both the principal challenge to industry and the sound basis on which we can plan for the future."

An address by U. M. Staebler, chief of the Civilian Reactor Branch, Division of Reactor Development, U. S. Atomic Energy

R. A. Clemensen, Photography

A BUFFET DINNER was served in the patio of the H. A. Carlberg residence located in Richland, Wash., to the representatives of the leading Tri-Cities engineering societies, the delegates from the Northwest District Sections, representatives of both the Pacific and Northwest Districts, and National AIEE officers and their wives. The affair was the President's Reception for AIEE President W. J. Barrett. Shown at the dinner are: (seated, *left to right*) Mrs. Carlberg, Mrs. Kistler, and Mrs. Barrett. President Barrett (*standing left*) and AIEE Director R. E. Kistler.

WP Photographic Laboratory

AIEE AND CIVIC LEADERS go over last minute details before the AIEE Pacific General Meeting opening general session, August 28, 1957, in the Pasco Senior High School, Pasco, Wash. *Left to right:* Rev. P. G. Nance, First Christian Church, who gave the Invocation; W. J. Barrett, AIEE president, who addressed the meeting; B. B. Smith, mayor of Kennewick, Wash., who delivered the Welcome Address; O. W. Hurd, manager of Benton County Public Utility District and general chairman of the Pacific General Meeting who presided; and H. A. Carlberg, specialist for general manager of General Electric Company Hanford Atomic Products Operation and chairman of Richland Section of AIEE who welcomed the engineers to the Tri-Cities and the Pacific General Meeting.

R. A. Clemensen, Photography

LEADERS IN THE BARBECUE for the more than 650 engineers and their wives and children attending the AIEE Pacific General Meeting in Pasco, Wash., are: *left to right, facing the camera*) F. J. Harless, General Electric Co. Hanford Works electrical maintenance; R. B. Britton, GE Company labor relations and Pacific General Meeting chairman of Entertainment Committee; and H. H. Hudlow, manager of Franklin County Public Utility District and chairman of the Barbecue Party.

Commission, was read by Dr. Glenn Wensch, senior project engineer of this program. The various experimental projects currently being developed in the United States were briefly outlined. He asserted that this country is capable of outbuilding and outproducing the rest of the world in the next five years with large prototype reactors, but emphasized that there is the important question of whether we want to achieve "economic nuclear power at any cost."

Student Program

Following a student luncheon on Thursday in the cafeteria of the Pasco Senior High School, a special session devoted to subjects of particular interest to students was held. R. E. Stephenson, chairman of District No. 9 Committee on Student Activities introduced the faculty counselors and student chairmen from the numerous colleges, universities, and technical schools in Districts No. 8 and No. 9. President Barrett then presented an informal address entitled "Knowledge and a Dual Responsibility." The session closed with the presentation of the first prize papers from Districts No. 8 and No. 9: "Rapid Plotting of Root Locus Diagrams" by R. D. Greenway, California State Polytechnic College, District No. 8, and "A Method for Designing Transistor Switching Circuits" by J. D. Burroughs of Oregon State College, District No. 9.

Technical Sessions

Human Engineering. A Wednesday afternoon session was devoted to the subject of human engineering and psychology in design. Dr. Maurice Rappaport of the Stanford Research Institute discussed human engineering as an aid to improving electronic equipment. He emphasized the growing need for designing electronic as well as other equipment so that it is tailor-made to fit man's relatively fixed physical, physiological, and psychological capabilities.

Dr. Jesse Orlansky of Dunlop and Associates, Stamford, Conn., presented a paper on advanced instrumentation, stressing the characteristics of current instruments and trends for the future.

A paper by Dr. J. W. Wissel and Dr. J. C. Lee, Lockheed Aircraft Corporation, outlined the company's experience with human engineering in the remote handling of nuclear radiation sources.

The session closed with "Human Factors in Maintenance of Complex Systems" by Dr. N. D. Warren of the University of Southern California and Psychological Services, Inc. He stated that the three approaches to the solution of maintenance problems are (1) the selection of mechanics having the greatest potential for diagnostic success, (2) improvement of training methods, and (3) the application of human engineering principles to design in order to improve maintainability.

Nucleonics. Three papers were presented at a Thursday morning session on nucleonics. The first, by A. R. Jones and R. L. Witzke of the Westinghouse Electric Corporation, outlined some of the operational problems of nuclear power plants. The text of this paper appears in the July 1957 issue of *Electrical Engineering*, pp. 572-77. Mr. Jones expanded on the portions of the original paper covering xenon effects.

D. S. Lewis of the General Electric Company discussed the operation of the Hanford reactors (see pp. 951-56 of this issue).

The training of operating personnel for nuclear power plants was described in a paper by W. G. McKeown, Westinghouse Electric Corporation. "Primarily," he stated, "the safe operation of a nuclear reactor should depend upon the administrative control and operation and, secondarily, upon the designed shutdown control system. Obviously, neither can be eliminated."

Television and Aural Broadcasting. In the first paper presented at a Thursday afternoon session, F. F. McClatchie of the Pacific Telephone and Telegraph Company described a modified microwave system for color television transmission. The system uses a new type of limiter and discriminator, each capable of linearity and stability greater than any of the standard forms tested. Many new features are included for easing maintenance and permitting precision alignment with a minimum of test equipment.

"A New Video Differential Phase and Gain Equalizer" by J. H. Clark, also of Pacific Telephone and Telegraph Company, outlines a technique for the improvement of color television circuits. The new equalizer employs the nonlinear impedance characteristics of devices such as germanium or silicon diodes to compensate for the undesirable nonlinearity of the circuits to which it is applied.

The session closed with a paper by L. B. Bennett, Pacific Telephone and Telegraph Company, describing an automatic frequency control circuit recently developed.

Safety. I. M. A. Garcia of the General Electric Company presided at a Friday morning session devoted to safety. In "A Compendium of Grounding Techniques for Personnel and Equipment Protection," H. E. Heddesheimer of General Electric discussed grounding methods for electrical distribution systems and equipment. He also stressed the importance of establishing definite maintenance schedules in order to assure that ground connections remain adequate, that ground circuits are not broken or burned, and that resistance to earth is within prescribed limits.

A paper by A. F. Ariey of Pacific Gas and Electric and E. P. Peabody of General Electric gave some comparisons between the safety and performance requirements of nuclear and conventional power plants. The paper states that operating experience with nuclear power plants will show them to compare favorably with conventional plants in safety, reliability, and ease of operation.

S. Levy of the General Electric Company presented a paper, "Safety in Nuclear Power Plants," reviewing the broad aspects of nuclear safety and discussing, in particular, three of its essential features. These deal with the need to (1) understand the possible sources of hazards and their associated problems; (2) counteract the hazards derived from these sources by proper precaution in design and operation, and by providing safety devices to minimize their effects; and (3) determine the potential danger and confine its consequences under emergency conditions.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

AIEE Future Meetings

EMC of EJC-SMC-NSF-NAS-NRC-WSE Engineering and Scientific Education Conference
Edgewater Beach Hotel
Chicago, Ill.
October 31-November 2, 1957

Machine Tool Conference*
Hotel Schroeder
Milwaukee, Wis.
November 4-6, 1957

AIEE-IRE-ISA Electrical Techniques in Medicine and Biology Conference*
Sheraton-Plaza Hotel
Boston, Mass.
November 6-8, 1957

Mid-Atlantic Textile Conference*
North Carolina State College
Raleigh, N. C.
November 14-15, 1957

Magnetism and Magnetic Materials Conference*
Park Sheraton Hotel
Washington, D. C.
November 18-21, 1957

AIEE-IRE-ACM Eastern Joint Computer Conference*
Park Sheraton and Shoreham Hotels
Washington, D. C.
December 9-13, 1957

AIEE-IRE-ASQC Reliability and Quality Control Conference
Statler Hotel
Washington, D. C.
January 6-8, 1958
(Final date for †TP—closed, ‡CP Syn.—closed, CPMs—Nov. 1)

AIEE-IRE Scintillation Counter Symposium
Shoreham Hotel
Washington, D. C.
January 27-28, 1958
(Final date for †TP—closed, ‡CP Syn.—Nov. 12, CPMs—Nov. 22)

Winter General Meeting
Hotel Statler, New York, N. Y.
February 2-7, 1958
(Final date for †TP—closed, ‡CP Syn.—Nov. 1, CPMs—Nov. 5)

AIEE-IRE-U of P Transistor and Solid State Circuits Conference
Philadelphia, Pa.
February 20-21, 1958
(Final date for †TP—Nov. 8, ‡CP Syn.—Dec. 3, CPMs—Dec. 13)

Textile Conference
Georgia Institute of Technology
Atlanta, Ga.
March 13-14, 1958
(Final date for †TP—Dec. 3, ‡CP Syn.—Dec. 26, CPMs—Jan. 7)

American Power Conference
Sherman Hotel, Chicago, Ill.
March 17-19, 1958
(Final date for †TP—Dec. 6, ‡CP Syn.—Jan. 1, CPMs—Jan. 10)

EJC Nuclear Congress
International Amphitheatre
Chicago, Ill.
March 17-21, 1958
(Final date for †TP—Dec. 6, ‡CP Syn.—Jan. 1, CPMs—Jan. 10)

Pulp and Paper Conference
North Carolina State College
Raleigh, N. C.
March 27-29, 1958
(Final date for †TP—Dec. 20, ‡CP Syn.—Jan. 15, CPMs—Jan. 24)

South West District Meeting
Tulsa, Okla.
March 31-April 2, 1958
(Final date for †TP—Dec. 20, §DP Syn.—Jan. 10, DPMs—Jan. 13)

AIEE-ASME Railroad Conference
Cleveland, Ohio
April 9-10, 1958
(Final date for †TP—Dec. 30, ‡CP Syn.—Jan. 24, CPMs—Feb. 3)

AIEE-IRE-ASME Automatic Techniques Conference
Statler Hotel
Detroit, Mich.
April 14-16, 1958
(Final date for †TP—Jan. 3, ‡CP Syn.—Feb. 25, CPMs—Feb. 7)

Middle Eastern District Meeting
Washington, D. C.
April 28-30, 1958
(Final date for †TP—Jan. 17, §DP Syn.—Feb. 7, DPMs—Feb. 11)

Great Lakes District Meeting
Michigan State University
East Lansing, Mich.
May 5-7, 1958
(Final date for †TP—Jan. 24, §DP Syn.—Feb. 7, DPMs—Feb. 11)

AIEE-IRE-ACM Western Joint Computer Conference
Ambassador Hotel
Los Angeles, Calif.
May 6-9, 1958
(Final date for †TP—Jan. 24, ‡CP Syn.—Feb. 18, CPMs—Feb. 28)

East Central District Meeting
Huntington, W. Va.
May 13-15, 1958
(Final date for †TP—Jan. 31, §DP Syn.—March 7, DPMs—March 11)

AIEE-IRE-RETMA-WCEMA Joint Electronic Components Conference
Los Angeles, Calif.
May 21-23, 1958
(Final date for †TP—Feb. 14, ‡CP Syn.—March 11, CPMs—March 21)

Domestic Appliances Conference
Hotel Morrison, Chicago, Ill.
May 27-29, 1958
(Final date for †TP—Feb. 14, ‡CP Syn.—March 11, CPMs—March 21)

AIEE-ISA-IAS National Telemetering Conference
Lord Baltimore Hotel
Baltimore, Md.
June 2-4, 1958
(Final date for †TP—Feb. 21, ‡CP Syn.—March 18, CPMs—March 28)

Summer General Meeting
Buffalo, N. Y.
June 22-27, 1958
(Final date for †TP—March 14, ‡CP Syn.—April 4, CPMs—April 7)

AIEE-IRE Nonlinear Magnetics and Magnetic Amplifiers Conference
Los Angeles, Calif.
August 6-8, 1958
(Final date for †TP—April 25, ‡CP Syn.—May 20, CPMs—May 30)

Pacific General Meeting
Sacramento, Calif.
August 19-22, 1958
(Final date for †TP—May 9, ‡CP Syn.—June 5, CPMs—June 6)

Petroleum Industry Conference
Baker Hotel, Dallas, Texas
September 15-17, 1958
(Final date for †TP—June 6, ‡CP Syn.—July 1, CPMs—July 11)

AIEE-IRE-RETMA-SMPTE National Electronics Conference
Chicago, Ill.
October 13-15, 1958
(Final date for †TP—July 4, ‡CP Syn.—July 29, CPMs—Aug. 8)

Machine Tools Conference
Statler Hotel, Hartford, Conn.
October 13-15, 1958
(Final date for †TP—July 4, ‡CP Syn.—July 29, CPMs—Aug. 8)

Fall General Meeting
Pittsburgh, Pa.
October 26-31, 1958
(Final date for †TP—June 27, ‡CP Syn.—Aug. 1, CPMs—Aug. 8)

Winter General Meeting
New York, N. Y.
February 1-6, 1959
(Final date for †TP—Oct. 14, ‡CP Syn.—Nov. 1, CPMs—Nov. 7)

*Final date for submitting papers—closed
†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
§DP Syn.—District Synopsis
DPMs—District Manuscript

Dr. Kelly Named Chairman of Campaign for United Engineering Center

APPOINTMENT of Dr. M. J. Kelly (F '31), president of Bell Telephone Laboratories, Inc., as general chairman of the business and industry campaign for the new $10 million United Engineering Center to be constructed on United Nations Plaza between 47th and 48th Sts. was announced recently by W. J. Barrett, president of United Engineering Trustees, Inc., and President of AIEE.

One of the nation's distinguished scientists, Dr. Kelly has had broad experience in directing research and development programs not only for the Bell System, but also on military projects undertaken by Bell Laboratories for the United States armed forces.

Dr. M. J. Kelly

Dr. Kelly has held many public service assignments in Washington, D.C., particularly with the Atomic Energy Commission, the Department of Commerce, and the Department of Defense. Among his many honors are the Air Force Exceptional Service Award and the 1953 Trophy of the Air Force Association, awarded ". . . for distinguished service to air power in the field of science."

Dr. Kelly also holds a Presidential Certificate of Merit for his contributions during World War II. He is a Life Member of the Alfred P. Sloan Foundation, Inc., and a trustee and member of the Corporation of Atoms for Peace Awards, Inc. He also is a member of the National Academy of Sciences and a Foreign Member of the Swedish Royal Academy of Sciences, and is associated with many other scientific professional societies.

A graduate of the Missouri School of Mines and Metallurgy, Dr. Kelly received the Ph.D. degree from the University of Chicago in 1918 and in the same year began his Bell System career as a research physicist. Before becoming president of Bell Laboratories in 1951, he had served as director of research and executive vice-president.

The campaign to raise funds for the construction of the new engineering center will start later this year, said Dr. Kelly. Initial efforts will be directed toward those businesses and industries which are most dependent upon the technologies represented by the engineering societies.

Societies associated with the project for the new Center are: AIEE; American Society of Civil Engineers; American Institute of Mining, Metallurgical and Petroleum Engineers; The American Society of Mechanical Engineers; and American Institute of Chemical Engineers.

Over 184,000 engineers are included in the membership of the associated societies and an invitation has been extended to 15 other American societies to make their headquarters in the Center.

In announcing the appointment of Dr. Kelly, Mr. Barrett said: "The present Engineering Societies Building at 29 W. 39th St. is today completely inadequate. Membership growth has multiplied many times during the past half century that the present building has served as headquarters. Present space requirements of associated societies are twice the square footage available in the old building. Our need is urgent and acute and is underlined by the inevitability of future growth."

AIEE Winter General Meeting Scheduled for February 2-7, 1958

THE WINTER GENERAL MEETING of AIEE will be held later next year, starting February 2 and continuing to February 7, 1958. Because of the large number of technical sessions, covering all six Technical Divisions of the Institute, meetings will take place in both the Statler and the Sheraton-McAlpin Hotels, New York, N. Y. As usual the Statler Hotel will be headquarters.

As this is being written long before the closing date of the papers, it is impossible to give even an approximation of the number of papers which will be presented; however, indications are that the number of technical and conference papers will exceed those of last year. The tentative program will be published in the January issue of *Electrical Engineering*.

Hotel Reservations

Blocks of rooms have been set aside at both the Statler and Sheraton-McAlpin Hotels as well as other hotels in the Pennsylvania and Grand Central zones as in past years. Details concerning hotels and rates will appear in the December issue of *Electrical Engineering*.

Although the week of the meeting is later this year than previously, the situation is still stringent and none of the hotels will guarantee any rooms not reserved prior to January 13, 1958. The committee suggests that requests be received prior to Christmas, as it is much more likely that the hotel desired will be able to accept it at that time.

Members are asked to send reservations to the hotel of their first choice, specifically referring to the AIEE meeting. Do not write to more than one hotel. If requests cannot be filled, the hotel will automatically refer requests to the Hotel Accommodations Committee, which will endeavor to obtain a similar reservation at another of the Convention hotels. It is further suggested that reservations beginning on Sunday, February 2 have a better chance of being acted upon favorably than those beginning on Monday or Tuesday.

Theater Tickets

Attention, all theater goers!

This year we will follow a different system for several reasons, and ask for co-operation. Requests for tickets should be sent directly to the agency, not to an AIEE committee.

In the December issue, details of tickets available and prices will be given. The agency will set aside blocks of tickets for members' use and will fill orders on a first-come first-served basis. All tickets will be left at the theater box office in the name of the purchaser.

Please wait for the December issue and be prepared to order immediately as no theater tickets will be sold at Meeting headquarters. Radio and television tickets will be available as usual at the information desk.

Smoker

A highlight of the Winter General Meeting will be the Smoker to be held Tuesday evening, February 4. Good food, good fellowship, and top quality entertainment will be the feature of this event which will take place in the Hotel Statler.

Attendance will be limited for the comfort of guests and ticket requests should be mailed at an early date. These requests should be addressed to AIEE Smoker Committee at 33 W. 39 St., New York 18, N.Y. When the price has been determined (see December *Electrical Engineering*) checks should be made payable to "Special Account, Secretary, AIEE" and sent to the same address.

Dinner-Dance

A Dinner-Dance will be held Thursday evening, February 6, in the Grand Ballroom of the Hotel Statler. General arrangements will be the same as those which proved enjoyable last year. Dress will be formal. Write soon for reservations at tables for 10. Address requests to AIEE Dinner-Dance Committee at 33 W. 39 St., New York 18, N.Y. When the price has been determined (see December *Electrical Engineering*) checks should be made payable to "Special Account, Secretary, AIEE" and sent to the same address.

Inspection Trips

A program that will be a combination of popular inspection trips from past

Informal Tea

This social gathering before the formal program begins has been enjoyed by more and more people each year. Make it a point to attend this year—Sunday afternoon, February 2, from 4 to 6 p.m., in the Georgian Room of the Statler. There will be no charge.

During this period the registration facilities will be open for those wishing to avoid the Monday morning rush.

years and others that have not been available in the past is being prepared. Radio City Music Hall, Brookhaven National Laboratory, and Western Electric at Kearney are among the repeats. One or two of the most modern local power stations, a cable plant, and a lighting clinic are probable new additions. A total of more than 18 individual inspection trips are planned.

Advance registration will be accepted for selected popular tours to enable out-of-towners to apply early for their tickets. This plan was tried last year and as a result of the success is being repeated. Preference will be given to all out-of-town applications for both advance and at-the-meeting requests.

Ladies Entertainment

The Ladies Entertainment Committee under the leadership of Mrs. C. T. Hatcher, is planning a varied and enjoyable program for the visiting guests.

Morning Coffee Hour will start each day at Ladies Headquarters. A "Get-Acquainted" Tea is scheduled for Monday February 3 with the remainder of the week being filled with an interesting tour, lovely luncheon-style show, and a dinner with entertainment.

Please note that each lady must bring her badge to Ladies Headquarters after registering with her husband before she can register for the program and entertainment. Headquarters will be located in the Washington Room of the Statler.

Winter General Meeting Committee

Members of the 1958 Winter General Meeting Committee are: D. M. Quick, chairman; R. T. Weil, Jr., vice-chairman; J. J. Anderson, secretary; L. F. Stone, budget co-ordinator and AIEE vice-president for District No. 3; H. Blackmon, chairman Technical Operations Department; J. A. Parrott, public relations; R. W. Gillette, general session; D. E. Winslow, hotel accommodations; T. C. Oliver, registration; J. A. Mulligan, inspection trips; R. R. Meola, monitors; H. B. Snow, smoker; W. F. Anselm, dinner-dance; Mrs. C. T. Hatcher, ladies entertainment; A. J. Cooper, ex-officio member (past-chairman).

Conference Planned on Electrical Techniques in Medicine and Biology

THIS YEAR, the Tenth Annual Conference on Electrical Techniques in Medicine and Biology will be held in Boston, Mass., November 6-8, at the Sheraton-Plaza Hotel. This annual meeting is sponsored by the Joint Executive Committee on Medicine and Biology of the three major electrotechnical societies of the Unites States. The purpose of this conference is to bring together electrical engineers, physicians, biologists, electronic instrumentologists, radiation physicists, physiologists, and others to discuss the latest electrical and electronic techniques in biology and medicine and to arrange symposia on current problems. The coming meeting is being sponsored by the AIEE, the Instrument Society of America, the Boston Chapter of the Professional Group on Medical Electronics of the Institute of Radio Engineers (IRE), and the Medical Physics Group of Boston who are acting as hosts to the meeting. The sessions are planned primarily as symposia in which the formal presentations are intended as preliminary steps to the stimulation of discussion and the free exchange of ideas.

Three morning scientific sessions and one evening panel discussion are planned together with three social hours which include appropriate refreshments. The afternoons are being left free for planned tours to laboratories in the area or personal sightseeing.

The tentative technical program for the conference follows.

Wednesday, November 6

8:00 a.m. Registration—Lobby

9:00 a.m. Instrumentation for Circulation Research—Oval Room

Chairman: Frank Noble, National Institute of Health, Bethesda, Md.

Radioisotope Recording of Rapid Transients in Blood Flow. *M. Higano, W. D. Cohen,* Memorial Hospital, Worcester, Mass.; *S. Aronow, G. L. Brownell,* Massachusetts General Hospital, Boston, Mass.

Theory of Measurement of Blood Flow by Dye Dilution Technique. *J. L. Stephenson,* National Heart Institute, Bethesda, Md.

An Ultrasonic Flowmeter for Measuring the Flow of Blood. *J. F. Herrick, J. A. Anderson, H. E. Essex,* Mayo Clinic and Mayo Foundation, Rochester, Minn.

1:45 p.m. Tour of New Plants on "Electronic Row," Route 128

1. Tracerlab—Hot Laboratory, tagged chemicals production; Keleket X-Ray Division; nuclear instrumentation projects

2. High Voltage Engineering—Van de Graaf generator; material sterilization; therapy; high voltage radiography

3. Sanborn—electrocardiograph and polygraph; transducer applications

6:00 p.m. Reception and Refreshments—Oval Room

Thursday, November 7

8:00 a.m. Registration—Lobby

9:00 a.m. Panel Discussion—Oval Room

"Problems in Sensory Perception and Replacement"

Chairman: W. E. Frank, Franklin Institute, Philadelphia, Pa.

Panelists: V. K. Zworykin, Rockefeller Institute, New York, N. Y.; Walter Rosenblith, Massachusetts Institute of Technology, Cambridge, Mass.; F. A. Geldard, Psychological Laboratory, University of Virginia, Charlottesville, Va.; H. E. Kallmann, consultant, New York, N. Y.; J. C. Button, Button Neurological Institute, East Orange, N. J.

1:45 p.m. Field Trip to Quartermaster Corps

Experimental laboratory for environmental research and human engineering, controlled environment laboratories for survival experiments

5:45 p.m. Informal Reception and Refreshments—Oval Room

8:00 p.m. Panel Discussion—Oval Room

Open Meeting, sponsored by the Boston Chapter of the Professional Group on Medical Electronics (IRE), "Education and Research in Biophysical Engineering"

Chairman: Graham Du Shane, American Association for the Advancement of Science, Washington, D. C.

Panelists: Murray Rosenberg, Massachusetts Institute of Technology; Gordon Brownell, Massachusetts General Hospital, Boston, Mass.; Walter Rosenblith, Massachusetts Institute of Technology

Friday, November 8

8:00 a.m. Registration—Lobby

9:00 a.m. Membrane Potentials and Ionic Transfer Phenomena—Oval Room

Chairman: D. O. Rudin, Eastern Pennsylvania Psychiatric Institute, Philadelphia, Pa.

Ion Selective Membranes for the Determination of Ionic Activities. *H. P. Gregor,* department of chemistry, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

Principles of Specific Ionic Interaction: Qualitative Aspects. *George Eisenman,* department of basic research, Eastern Pennsylvania Psychiatric Institute, Philadelphia, Pa.

Principles of Specific Ionic Interaction: Quantitative Aspects. *G. N. Ling,* department of basic research, Eastern Pennsylvania Psychiatric Institute, Philadelphia, Pa.

The Kinetics of the Action Potential at the Node of Ranvier. *Paul Mueller,* department of basic research, Eastern Pennsylvania Psychiatric Institute, Philadelphia, Pa.

2:00 p.m. Informal Laboratory Visits, Boston Area

Massachusetts Institute of Technology: 1. The Medical Reactor. A reactor in construction primarily for medical research and therapy. This includes a complete operating room. 2. Radioactivity Center; Health Physics Laboratories. 3. Biological Labratories.

Massachusetts General Hospital: 1. Ultrasonics Laboratory. 2. Radio-Arsenic Scanning Laboratory. 3. Thyroid Laboratory.

Boston Sightseeing Tours (an alternate): Persons interested in the aforementioned or other institutions should contact the Tours Committee representative at time of registration.

These meetings are being planned by the following committees to whom requests for information should be addressed:

Registration Chairman—D. E. Williamson, Williamson Development Co., Inc., 317 Main St., West Concord, Mass.

Program Chairman—T. F. Hueter, Raytheon Manufacturing Co., Wayland, Mass.

Entertainment Chairman—W. R. Brewster, Jr., Massachusetts General Hospital, Boston 14, Mass.

Publicity Chairman—C. Berkley, RCA Laboratories, Princeton, N.J.

Local Arrangements Chairman—Saul Aronow Massachusetts General Hospital, Boston 14, Mass.

Tours Chairman—Yehuda Golahny, Raytheon Manufacturing Co., Waltham 54, Mass.

Local Publicity Committee—Yehuda Golahny, chairman; Miss Adele Khoury, Dept. of Anesthesiology, Massachusetts General Hospital, Boston 14, Mass; William Brewster, Dept. of Anesthesiology, Massachusetts General Hospital, Boston 14, Mass.

Conference Chairman—Dr. D. A. Holaday, assistant professor of anesthesiology, Columbia University College of Physicians and Surgeons, New York 32, N. Y.

Treasurer—M. B. Levene, Dept. of Radiology, Lemuel Shattuck Hospital, 170 Morton St., Jamaica Plains 30, Mass.

AIEE Headquarters—R. S. Gardner, Assistant Secretary Technical Activities, 33 West 39th St., New York 18, N.Y.

The registration fee for the entire conference and field trips including bus transportation is $6; for technical sessions only, $3.

Petroleum Industry Conference Outstanding Success in Philadelphia

THE FOURTH ANNUAL AIEE Petroleum Industry Conference held at Philadelphia's (Pa.) Sheraton Hotel, Sept. 9-11, 1957, was an outstanding success with an attendance in excess of 400. Participants came from 21 states, Canada, and Venezuela. The conference had never before been held in the East and the response was most gratifying to all concerned with its planning. The conference chairman was A. L. R. Maynard, General Electric Company (GE), and the vice-chairman was S. P. Axe, Atlantic Refining Company.

The general session on the morning of September 9, under the chairmanship of L. B. Oberhelman, Standard Oil Company (Ind.), was welcomed to Philadelphia by L. C. Purdey, deputy director of commerce for the city. W. J. Barrett, president of AIEE, outlined the activities of the Institute and described the interrelation between the various technical and professional societies.

The keynote address was delivered by Dr. L. M. Goldsmith, general manager of engineering and construction of the Atlantic Refining Company. Dr. Goldsmith reviewed the astonishing changes that have transpired in the use of electric equipment by the petroleum industry since he first became connected with the industry some 40 years ago. He revealed that 10% of the nation's refining capacity is located in Philadelphia and the Delaware Valley area. Dr. Goldsmith stressed the importance of a reliable power supply and the need for continued co-operation between the petroleum and electric utility industries.

DR. L. R. FINK of General Electric shows the 10 "small things big in research" which he described in his talk, "A Handful of the Future," at the fourth annual National Petroleum Industry Conference sponsored by the AIEE in Philadelphia, Pa., September 9-11, 1957.

Research Information Services, GE Research Laboratory

The general session's main speaker was Dr. L. R. Fink, general manager of GE's X-ray department and formerly general manager, research application department, GE Research Labs, Schenectady, N. Y. Dr. Fink, in his talk entitled "A Handful of the Future," emphasized that industry is learning that it is just as important for its researchers to breathe freely in the atmosphere of fundamental science as it is for them to plant their feet among the down-to-earth problems of product development. He showed his audience 10 small items which, although physically so small he could hold them all in one hand, are "big in research." Included in his "handful" were some of GE's man-made diamonds, new types of transistors, a tiny ceramic vacuum tube that works at high temperatures, and tiny whiskers of iron that have set a world record for the strength of metals.

The main speaker at the conference luncheon on September 9 was H. A. Stewart, director, Office of Oil and Gas, U. S. Department of the Interior. His talk "Oil in an Expanding Economy and in National Security" described the operation of the Office of Oil and Gas in supplying information to Government agencies and the petroleum and gas industries. He stated that probably the most important function of his office was the continuous appraisal of the United States' domestic petroleum and gas capabilities as well as the foreign capabilities which may be available to meet the country's needs and those of the friendly nations of the free world. Mr. Stewart underlined the importance of the Middle East with his statement that its petroleum reserves are almost three times that of the entire Western Hemisphere.

A total of 21 papers were given during the technical sessions on the afternoon of September 9 and morning of September 11. Each session was divided into three divisions—Production, Transportation, and Refining. The respective chairmen were: M. H. Halderson, Phillips Petroleum Corporation; M. A. Hyde, Westinghouse Electric Corporation; H. M. Stewart, Humble Oil and Refining Company.

The three inspection trips arranged for September 10 lasted all day. One included the new Tidewater Oil Company refinery at Delaware City, Del. and the adjacent Delaware Power and Light Company generating station; also stops at Sun Oil's Marcus Hook, Pa., and Atlantic Refining's Philadelphia refineries. A second group visited Texas Eastern Transmission Corporation's pumping station at Grantville, Pa.; Atlantic Refining's Boot Pipeline Station at Exton, Pa.; and the Macungie, Pa., pumping stations of the Buckeye Pipeline Company and Tuscarora Pipeline Company. The third group inspected the Westinghouse turbine plant at Lester, Pa.; General Electric's Switchgear Laboratories and plant at South Philadelphia and Philadelphia's world famous Franklin Institute.

Members of the conference Executive Committee include: R. S. Gardner, AIEE Headquarters; G. B. Schleicher, Philadelphia Electric Company; J. M. Crothers, Catalytic Construction Company; T. H.

MacCauley, General Electric Company; A. L. Jones, Sun Oil Company; P. H. Weinberg, Philadelphia Electric Company; and F. C. Somers, Esso Research and Engineering.

Operating Committee chairmen were: publicity and hospitality—J. M. Butler, Jr., General Electric Company; inspection trips—H. E. Lanphear, Allis-Chalmers Manufacturing Co.; budget and finance—E. G. Carothers, Westinghouse Electric Corporation; technical program—W. O. Mascaro, Atlantic Refining Company; registration and hotel—F. A. Leinberger, General Electric Co.; printing and programming—G. W. Gordon, Philadelphia Electric Co.; ladies program—Mrs. W. O. Mascaro.

Machine Tool Conference Will Be Held November 4-6

Interest in the Annual Machine Tool Conference of the AIEE is evidenced by the growth in registration over the years, the names and reputations of technical paper contributors, and their company affiliations. Registration at the 1957 conference, to be held November 4-6, at the Hotel Schroeder, Milwaukee, Wis., is expected to exceed last year's 700 record.

The tentative technical program for the ninth annual conference appeared in the October issue of *Electrical Engineering*, pages 900-01. In part, it deals with, and in effect, it presents the first reports of experience with the various versions of "Stored Intelligence Control" for a number of important applications made in the past few years. It also deals with recent and comparatively little known developments in electric motors. Synchronous induction, "Pancake" types, and fluid cooled versions are treated. Advances in the art of control also are described. The range extends from static proximity pilot control apparatus to electronic and static magnetic motor controller design and application, with some emphasis on needs of inherent safety.

A total of six plant visits are planned during the conference, three for Monday morning, and three for Wednesday afternoon. Plants to be visited are:

Monday Morning, November 4

Louis Allis Co. This visit will present a tour of the entire plant, including newly added manufacturing and office facilities. Luncheon will be served.

Kearney & Trecker Co., Main Plant. In this standard machine division, over 650 precision machine tools and 2,000 skilled craftsmen produce precision milling machines employed in metalworking industries the world over since 1898. Luncheon will be served.

Kearney & Trecker Co., Special Machinery Plant. This new, modern $15.5 million plant is devoted to designing and building special machinery employed in the manufacture of automobiles, aircraft frames, and numerous consumer durable goods products.

Wednesday Afternoon, November 6

Allen-Bradley Co. During this visit, most interesting phases of manufacture and assembly of motor control and allied products will be viewed.

Cutler-Hammer, Inc., 30th St. Plant. This plant is devoted to the assembly and test of large motor control and special controllers such as those for machine tools.

Square D Company. First stop will be at the new, modern, highly mechanized Good Hope Plant, devoted to volume production of standard apparatus, followed by a visit to the special control department of the Main Plant.

SHOWN at the AIEE Petroleum Industry Conference are (*left to right*) A. L. R. Maynard, General Electric Company, conference chairman; W. J. Barrett, New Jersey Bell Telephone Co., AIEE President; Dr. L. R. Fink, General Electric Company, general session main speaker; R. S. Gardner, assistant secretary, AIEE Headquarters; Dr. L. M. Goldsmith, Atlantic Refining Co., general session keynote speaker.

Provisions Made for Overseas Chapters of AIEE

Overseas Chapters of the Institute may now be organized in all countries outside the territorial limits specified for Sections, that is, outside the United States, Alaska, Hawaii, Puerto Rico, Mexico, and Canada. The Constitution and Bylaws now provide for such Overseas Chapters in order to carry out more effectively the aims of the Institute abroad.

Their organization and activities would be similar to those prescribed for Sections. To form an Overseas Chapter, a petition for approval of the particular Overseas Chapter should be signed by 10 members residing within the territory. Any such chapters should be self-supporting financially, and observers would be most welcome at the Section Delegates Conference at the AIEE Summer General Meeting, but without voting privileges or travel allowance.

All Overseas Chapters would be administered by the Metropolitan New York District so any preliminary inquiries should be sent to L. F. Stone, Vice-President, District No. 3, General Electric Company, 744 Broad St., Newark 2, N. J.

Mid-Atlantic Textile Conference Being Held this Month

The Mid-Atlantic Textile Conference, sponsored by the AIEE Textiles Subcommittee, will be held at the North Carolina State College, Raleigh, N. C., November 14-15, 1957. Chairman for this year's conference is H. E. Strock.

The tentative technical program of papers follows.

The Co-ordination of Circuit Breakers and Fuses in Textile Mills. *E. R. Burgin*, ITE Circuit Breaker Co.

A-C Group for Modern Textile Machines. *C. G. Helmick*, Westinghouse Electric Corporation

Clutch-Brake Motor Applications to Textile Machinery. *Ed Turner*, Diehl Manufacturing Co.

Basic Control Circuits. *M. R. Brice*, Cutler Hammer, Inc.

An Ideal Electrical Layout for a Textile Mill. *Morris Gelders*, Lockwood-Greene, Engineers

Starting and Maintenance of Range Drives. *C. L. Griffin*, General Electric Company, Systems Application Section

Standards Committee Report on Electrical Equipment. A Member of Textile Subcommittee

Du Pont's Engineering Approach to Materials Handling. *C. B. Putney*, E. I. DuPont de Nemours & Co.

Fundamentals of D-C Circuits and D-C Motors. *Dr. G. B. Hoadley*, North Carolina State College

Electrical and Mechanical Modernization at a Cotton Mill. *G. V. Fowler*, Henderson Cotton Mills

What's New in Textile Machinery? *M. C. May*, Textile Industries and Southern Power and Industry

Program Set for Magnetism Conference

The 1957 Conference on Magnetism and Magnetic Materials, sponsored by the Magnetics Subcommittee of the Basic Sciences Committee of AIEE. will be held at the Sheraton Park Hotel, Washington, D. C., November 18-21.

The tentative technical program for the conference follows.

Monday, November 18

9:30 a.m. Opening Remarks—Sheraton Hall

J. E. Goldman, conference chairman

9:45 a.m. Invited Papers—Sheraton Hall

G. T. Rado, presiding

Paper To Be Announced. *L. Neel*, Institut Fourier, Grenoble, France

Physical Phenomena Involved in Maser Operation. *C. L. Hogan*, Harvard University

Masers. *C. H. Townes*, Columbia University

Time Decrease of Permeability in Iron. *G. W. Rathenau*, Natuurkundig Laboratorium, University of Amsterdam, Netherlands

Observations on Magnetism Research in Europe. *J. S. Smart*, U. S. Office of Naval Research, London, England

2:00 p.m. Magnetization Reversal: Mostly in Thin Films—Sheraton Hall

C. P. Bean, presiding

Magnetic Anisotropy and Relaxation in Thin Films. (invited paper) *D. O. Smith*, Lincoln Laboratory, Massachusetts Institute of Technology

Magnetization Reversal in Thin Films of Permalloy. (invited paper) *C. D. Olson, A. V. Pohm*, Remington Rand Univac

Rotational Model of Flux Reversal in Square Loop Soft Ferromagnets. *E. M. Gyorgy*, Bell Telephone Laboratories, Inc.

Transverse Flux Change in Soft Ferromagnets. *F. B. Humphrey*, Bell Telephone Laboratories, Inc.

The Effects of Heat Treatment of Thin Ferromagnetic Films at Intermediate Temperatures. *E. N. Mitchell*, Remington Rand Univac

Reversible Rotation in Magnetic Films. *R. M. Sanders, T. D. Rossing*, Remington Rand Univac

Steady-State and Pulse Measurement Techniques for Thin Ferromagnetic Films in the Frequency Range 0.3 to 5,000 Mc. *D. O. Smith, G. P. Weiss*, Lincoln Laboratory, Massachusetts Institute of Technology

Ferromagnetic Resonance in Ultrathin Films. *M. H. Seavey, Jr., P. E. Tannenwald*, Lincoln Laboratory, Massachusetts Institute of Technology

Domain Walls and Patterns in Thin Permalloy Films. *E. E. Huber, Jr., D. O. Smith, J. B. Goodenough*, Lincoln Laboratory, Massachusetts Institute of Technology

Motion Pictures of Magnetic Writing on Thin Films of MnBi. *H. J. Williams, R. C. Sherwood*, Bell Telephone Laboratories, Inc.

2:00 p.m. Small Particles and Permanent Magnets—Continental Room

W. F. Brown, Jr., presiding

Electron Microscopical Investigation of the Metallographic Structure of Ticonal-G (Alnico V). *J. J. deJong, J. M. G. Smeets, H. B. Haanstra*, Philips Research Laboratories, Eindhoven, Netherlands

Relation between Colloid Pattern and Permanent Magnet Precipitate during the Magnetization Reversal in Alnico V. *K. J. Kronenberg, R. K. Tenzer*, The Indiana Steel Products Company

Phase Analysis of Alnico V Based on Temperature Effects. *R. K. Tenzer, K. J. Kronenberg*, The Indiana Steel Products Company

Physical and Magnetic Properties of Elongated Single-Domain Fine Particle Iron and Iron-Cobalt Permanent Magnets. *R. B. Falk, E. J. Yamartino, R. C. Lever*, Measurement Laboratory, General Electric Company

Effects of Magnetic Fields upon Anisotropic Iron Crystals. *J. H. L. Watson*, Edsel B. Ford Institute for Medical Research; *A. Arrott*, Scientific Laboratory, Ford Motor Company; *M. W. Freeman*, M. W. Freeman Company

Loss of Exchange Coupling in the Surface Layers of Ferromagnetic Particles. *F. E. Luborsky*, instrument department, General Electric Company

Ferromagnetic Resonance Studies of Some Solid-State Transformers. *D. S. Rodbell*, General Electric Research Laboratory

Magnetic Determination of Shape Distribution of Single Domain Powders. *C. E. Johnson, Jr., W. F. Brown, Jr.*, Minnesota Mining and Manufacturing Company

Magnetic Measurements on Some Precipitating Systems. *A. E. Berkowitz, P. J. Flanders*, The Franklin Institute Laboratories

Precipitation and Magnetic Annealing in a Copper-Cobalt Alloy. *J. J. Becker*, General Electric Research Laboratory

Tuesday, November 19

9:00 a.m. Ferromagnetic Resonance: Line Structures—Sheraton Hall

J. K. Galt, presiding

Resonant Modes of Ferromagnetic Spheroids. (invited paper) *L. R. Walker*, Bell Telephone Laboratories, Inc.

Multiplicities of the Uniform Precessional Mode in Ferrimagnetic Resonance. *I. H. Solt, Jr., R. L. White, J. E. Mercereau*, Hughes Research Laboratory

Ferromagnetic Resonance and Nonlinear Effects in Yttrium-Iron Garnet. *R. C. LeCraw, E. G. Spencer, C. S. Porter*, Diamond Ordnance Fuze Laboratories

Low-Temperature Spin Wave Resonance at 3,000 and 4,000 Mc per Second in a Permalloy Having Nearly Zero Magnetocrystalline Anisotropy. *J. R. Weertman, G. T. Rado*, U. S. Naval Research Laboratory

Effect of Electronic Mean-Free Path on Spin Wave Resonance in Ferromagnetic Metals. *G. T. Rado*, U. S. Naval Research Laboratory

Ferromagnetic Dynamical Response. *H. B. Callen*, department of physics, University of Pennsylvania

Dipole Narrowing of Inhomogeneously Broadened Ferromagnetic Resonance Lines. *A. M. Clogston*, Bell Telephone Laboratories, Inc.

Origin of Ferromagnetic Resonance Line Broadening in Manganese Rich Manganese Ferrites. *S. E. Harrison*, RCA Laboratories; *H. S. Belson, C. J. Kriessman*, Remington Rand Univac

Ferromagnetic Resonance in Uniaxial Polycrystalline Materials. *C. A. Morrison, N. Karayianis*, Diamond Ordnance Fuze Laboratories

Ferromagnetic Resonance in Polycrystalline Nickel Ferrite Aluminate. *E. Schlomann, F. R. Zeender*, Raytheon Mfg. Company

Damping and the Dispersion Relations in Antiferromagnetic Resonance. *E. S. Dayhoff*, U. S. Naval Ordnance Laboratory

9:00 a.m. Magnetic Alloys: Mostly Oriented—Continental Room

J. K. Stanley, presiding

Magnetic Anisotropy Induced by Magnetic Annealing and by Cold Working of Ni_3Fe Crystal. (invited paper) *Soshin Chikazumi*, department of physics and chemistry, Gakushuin University, Mejiro, Tokyo, Japan

The Effect of Sample Thickness on the Field Annealing of 6.5% Si-Fe. *P. A. Albert*, Magnetic Materials Development Section, Westinghouse Electric Corporation

Recrystallization of MnBi Induced by a Magnetic Field. *O. L. Boothby, D. H. Wenny, E. E. Thomas*, Bell Telephone Laboratories, Inc.

Effects of Composition and Processing Variables on the Magnetic Properties of the Nominal 50% Nickel, 50% Iron Alloy. *M. J. Savitski*, materials engineering department, Westinghouse Electric Corporation

Orientation Study of Ultrathin Molybdenum Permalloy Tape. *P. E. Koh*, Allegheny Ludlum Steel Corporation

The Development of Preferred Orientations in Silicon-Iron. *J. R. Brown*, Metal Physics Section, G.K.N. Group Research Laboratory, Birmingham New Road, Lanesfield, Wolverhampton, England

The (110) 001 Secondary Recrystallization Texture in Silicon-Iron. *H. C. Fiedler*, General Electric Research Laboratory

Magnetic Properties of Cube Textured Magnetic Sheet. *J. L. Walter, W. R. Hibbard, H. C. Fiedler, H. E. Grenoble, R. H. Fry, P. G. Frischmann*, General Electric Company

Cube Texture in Body Centered Cubic Magnetic Alloys. *G. Wiener, P. A. Albert, R. H. Trapp*, Westinghouse Electric Corporation; *M. F. Littmann*, Armco Steel Corporation

Low Magnetic Resonance in the High Aluminum Iron Alloys. *D. Pavlovic, K. Foster*, materials engineering department, Westinghouse Electric Corporation

Effects of Elastic Bending on Magnetic Properties of Oriented Silicon-Iron. *R. W. Cole*, Crucible Steel Company of America

2:00 p.m. Magnetic Moments and Crystal Structures of Oxides—Sheraton Hall

L. R. Maxwell, presiding

The Effect of Hydrostatic Pressure and Temperature on the Magnetic Properties of a Nickel-Zinc Ferrite. *C. Q. Adams, C. M. Davis, Jr.*, U. S. Naval Ordnance Laboratory

The Preferential Volatilization of Cations from Ferrites during Sintering. *J. M. Brownlow*, International Business Machines Corporation, Research Center

Some Properties of Quenched Magnesium Ferrites. *D. J. Epstein, B. Frackiewicz*, Laboratory for Insulation Research, Massachusetts Institute of Technology

Ionic Valences in Manganese-Iron Spinels. *A. H. Eschenfelder*, International Business Machines Corporation, Research Center

Substitution for Iron in Ferrimagnetic Yttrium-Iron Garnet. *M. A. Gilleo, S. Geller*, Bell Telephone Laboratories, Inc.

Some Ferrimagnetic Properties of the System $Li_2Ni_{1-x}O$. *J. B. Goodenough, D. G. Wickham*, Lincoln Laboratory, Massachusetts Institute of Technology; *W. J. Croft*, RCA Laboratories

Effect of Thermal History on the Antiferromagnetic Transition in Zinc Ferrite. *D. M. Grimes, E. F. Westrum, Jr.*, University of Michigan

Magnetic Germanates Isostructural with Garnet. *A. Tauber*, U. S. Army Signal Engineering Laboratories; *E. Banks*, Polytechnic Institute of Brooklyn; *H. Kedesdy*, U. S. Army Signal Engineering Laboratories

Some Magnetic and Crystallographic Properties of the System $LaMn_{1-x}Ni_xO_3$. *A. Wold, R. J. Arnott, J. B. Goodenough*, Lincoln Laboratory, Massachusetts Institute of Technology

Crystal Growth of Magnetic Garnets. *J. W. Nielsen*, Bell Telephone Laboratories, Inc.

Antiferromagnetic Structures of MnS_2, $MnSe_2$ and $MnTe_2$. *L. M. Corliss, N. Elliott, J. M. Hastings*, Brookhaven National Laboratory

2:00 p.m. Applications and Testing—Continental Room

A. D. Franklin, presiding

Measurement of Losses of Magnetic Materials at High Inductions, at Frequencies Up to 100

Megacycles. *I. Bady*, U. S. Army Signal Engineering Laboratories

Measurements of the Property of Various Ferrites Used in Magnetically Tuned Resonant Circuits in the 2.5 to 45 Mc Region. *P. P. Lombardini, R. F. Schwartz, R. J. Doviak*, University of Pennsylvania

The Behavior of the TE Modes in Ferrite Loaded Rectangular Waveguide in the Region of Ferrimagnetic Resonance. *W. J. Crowe*, Bell Telephone Laboratories, Inc.

Energy Distribution in Partially Ferrite Filled Waveguides. *J. E. Tompkins*, Diamond Ordnance Fuze Laboratories

A Miniaturized Resonant Antenna Using Ferrites. *D. M. Grimes*, University of Michigan

An Appraisal of Permanent Magnet Materials for Magnetic Focusing of Electron Beams. *M. S. Glass*, Bell Telephone Laboratories, Inc.

The Performance of Permanent Magnets at Elevated Temperatures. *W. H. Roberts*, General Electric Company

The Micro-Uniformity of Permanent Magnet Materials. *L. I. Mendelsohn*, General Electric Company

Understanding and Predicting Permanent Magnet Performance by Electrical Analog Methods. *R. J. Parker*, General Electric Company

Method for Measuring Saturation Magnetization in Ring Samples. *C. D. Graham, Jr.*, General Electric Research Laboratory

Some Aspects of Tempering 3¼% Silicon Iron via Time Decay of Permeability. *E. S. Anolick, J. Singer*, transformer laboratories department, General Electric Company

Materials Problems in Magnetic Suspension Apparatus. *J. B. Breazeale*, Bill Jack Scientific Instrument Company

Wednesday, November 20

9:00 a.m. Ferromagnetic Resonance: Nonlinear Effects and Garnets—Sheraton Hall

C. L. Hogan, presiding

Origin and Use of Instability in Ferromagnetic Resonance. (invited paper) *H. Suhl*, Bell Telephone Laboratories, Inc.

A Solid-State Microwave Amplifier and Oscillator Using Ferrite. *M. T. Weiss*, Bell Telephone Laboratories, Inc.

A New Type of Ferromagnetic Microwave Amplifier. *C. L. Hogan*, Harvard University

Microwave Frequency Conversion Studies in Magnetized Ferrites. *E. W. Skomal*, Sylvania Electric Products, Inc., Microwave Physics Laboratory

Spin-Lattice Relaxation Time in Yttrium-Iron Garnet. *R. T. Ferrar*, Diamond Ordnance Fuze Laboratories

Ferromagnetic Resonance in Gadolinium-Iron Garnet. *B. A. Calhoun, W. V. Smith, J. Overmeyer*, International Business Machines Corporation, Research Center

Ferromagnetic Resonance in Yttrium-Iron Garnet at Low Frequencies. *E. G. Spencer, R. C. LeCraw, C. S. Porter*, Diamond Ordnance Fuze Laboratories

Microwave Properties of Polycrystalline Rare-Earth Garnets. *M. H. Sirvetz, J. E. Zneimer*, Raytheon Mfg. Company, Research Division

Ferromagnetic Resonance in Single Crystals of Rare-Earth Garnet Materials. *R. V. Jones, G. P. Rodrigue, W. P. Wolf*, Gordon McKay Laboratory, Harvard University

2:00 p.m. Anisotropy and Magnetostriction—Sheraton Hall

R. M. Bozorth, presiding

Temperature Dependence of the Magnetocrystalline Anisotropy Coefficients in Cubic Crystals. *E. Callen*, National Security Agency; *J. L. Jackson*, National Bureau of Standards; *H. B. Callen*, department of physics, University of Pennsylvania

Temperature Dependence of Ferromagnetic Anisotropy. *W. J. Carr, Jr.*, Westinghouse Electric Corporation

Magnetocrystalline Anisotropy of Mg-Fe Ferrites: Temperature Dependence, Ionic Distribution Effects, and the Crystalline Field Model. *V. J. Folen, G. T. Rado*, U. S. Naval Research Laboratory

Magnetic Annealing in Cobalt-Iron Ferrite Single Crystals. *L. R. Bickford, Jr., J. M. Brownlow, R. F. Penoyer*, International Business Machines Corporation, Research Center

Magnetization Processes in Heat-Treated Single Crystal Cobalt Ferrite. *S. Foner*, Lincoln Laboratory, Massachusetts Institute of Technology; *J. O. Artman*, Gordon McKay Laboratory, Harvard University

Crystallographic and Magnetic Studies of the System $NiFe_{2-x}Mn_xO_4$. *P. K. Baltzer, J. G. White*, Radio Corporation of America, David Sarnoff Research Center

Origin of Anisotropic Effects in $Co_xFe_{3-x}O_4$. *J. C. Slonczewski*, International Business Machines Corporation, Research Center

Theory of Magnetostriction and g-Factor in Ferrites. *Noboru Tsuya*, Research Institute of Electrical Communications, Tohoku University, Sendai, Japan

The Relationship between Single Crystal and Effective Polycrystalline Anisotropy Constants in Ferrites. *C. J. Kriessman*, Remington Rand Univac; *S. E. Harrison*, RCA Laboratories; *H. S. Belson*, Remington Rand Univac

Exchange Anisotropy in the Iron–Iron Oxide System. *W. H. Meiklejohn*, General Electric Research Laboratory

Magnetostriction and Elastic Properties of Ferromagnetic Substances at High Magnetic Fields. *H. Sato*, Scientific Laboratory, Ford Motor Company

Thursday, November 21

9:00 a.m. Magnetization Processes: Reversals and Losses—Sheraton Hall

J. R. Weertman, presiding

Domain Wall Motion in Metals. (invited paper) *R. W. DeBlois*, General Electric Research Laboratory

Preparation and Properties of Crystal-Oriented Ferroplana Samples. *A. L. Stuijts, H. P. J. Wijn*, Philips Research Laboratories, Eindhoven, Netherlands

A Rigorous Approach to the Theory of Ferromagnetic Microstructure. *W. F. Brown, Jr.*, central research department, Minnesota Mining and Mfg. Co.

The Magnetization Curve of the Infinite Cylinder. *A. Aharoni, S. Shtrikman*, department of electronics, The Weizmann Institute of Science, Rehovot, Israel

A Model for Nonlinear Flux Reversals of Square Loop Polycrystalline Magnetic Cores. *M. K. Haynes*, International Business Machines Corporation, Research Center

Temperature Dependence of Microwave Permeabilities for Polycrystalline Ferrite and Garnet Materials. *J. Nemarich, J. C. Cacheris*, Diamond Ordnance Fuze Laboratories

The Effect of Cobalt on the Relaxation Frequency of Nickel-Zinc Ferrite. *F. J. Schnettler, F. R. Monforte*, Bell Telephone Laboratories, Inc.

The Switching Properties of Permalloy Cores of Varying Coercivity. *T. D. Rossing, V. J. Korkowski*, Remington Rand Univac

Rotational Loss Measurements on Some Ferrites. *J. M. Kelly*, Armour Research Foundation of Illinois Institute of Technology

The Temperature Dependence of the Attenuation of Ultrasound in a Nickel Single Crystal from 77 to 650 K. *F. West*, Texas Instruments, Inc.

Magnetic Fluctuations in Molybdenum Permalloy. *J. J. Brophy*, Armour Research Foundation of Illinois Institute of Technology

9:00 a.m. Magnetic Apparatus and Techniques—Burgundy Room

T. R. McGuire, presiding

A New Concept in Large-Size Memory Arrays—The Twister. *A. H. Bobeck*, Bell Telephone Laboratories, Inc.

Analysis and Operation of a Ferrite Plate Switch Driven Memory System Using Two Holes per Bit. *V. L. Newhouse, M. M. Kaufman*, Bizmac Engineering, Radio Corporation of America

Recent Advances in the Design of High Field D-C Solenoid Magnets. *H. H. Kolm*, Lincoln Laboratory, Massachusetts Institute of Technology

AIEE Memphis Section Officers

AMONG THE NEW OFFICERS installed at the recent annual meeting of the Memphis Section of AIEE were: (left to right) C. E. Metcalf, director; R. D. Barrett, chairman; L. H. Heyman, secretary; A. H. Beasley, director; George Davis, past chairman; and W. L. Wood, treasurer.

Further Development of the Vibrating Coil Magnetometer. *K. Dwight, N. Menyuk, D. Smith,* Lincoln Laboratory, Massachusetts Institute of Technology

An Improved Torque Magnetometer. *W. S. Byrnes,* Westinghouse Electric Corporation

A Transparent Ferromagnetic Light Modulator Using Yttrium-Iron Garnet. *C. S. Porter, E. G. Spencer, R. C. LeCraw,* Diamond Ordnance Fuze Laboratories

Design of Optimum Inductors Using Magnetically Hard Ferrites in Combination with Magnetically Soft Materials. *J. T. Ludwig,* Minneapolis-Honeywell Regulator Company

Pulse Generator Based on High-Shock Demagnetization of Ferromagnetic Material. *R. W. Kulterman,* Sandia Corporation

A New Magnetic Core Loss Comparator. *R. E. Tompkins, L. N. Stauffer,* General Electric Company

The Preparation of Alnico VII Castings with Improved Physical Properties. *D. H. Wenny, K. M. Olsen,* Bell Telephone Laboratories, Inc.

Skull-Cap Method for Magnetizing Bowl-Shaped Magnetron Magnets. *F. X. MacDonough, Jr.,* Bomac Laboratories, Inc.

2:00 p.m.—Magnetic Moments and Crystal Structures of Metals—Sheraton Hall

J. J. Becher, presiding

Magnetometallurgy Applications and Methods. (invited paper) *A. Arrott,* Scientific Laboratory, Ford Motor Company

Suggestions Concerning the Role of Covalence in Transition Elements and Their Alloys. *J. B. Goodenough,* Lincoln Laboratory, Massachusetts Institute of Technology

Transitions from Ferromagnetism to Antiferromagnetism in Iron Aluminum Alloys. *A. Arrott, H. Sato,* Scientific Laboratory, Ford Motor Company

Some Unusual Magnetic Properties of Ni_2Mn. *J. S. Kouvel, C. D. Graham, Jr., J. J. Becker,* General Eletcric Research Laboratory

Magnetic Properties of Dilute Magnetic Alloys and of the Rare-Earth Metals. *G. W. Pratt, Jr.,* Lincoln Laboratory, Massachusetts Institute of Technology

Further Magnetic and X-ray Diffraction Studies on Iron Rich Iron-Aluminum Alloys. *A. Taylor, R. M. Jones,* Westinghouse Research Laboratory

Magnetic Moments and Apparent Molecular Fields in Some Rare-Earth Metals and Compounds. *W. E. Henry,* U. S. Naval Research Laboratory

2:00 p.m. Domain Patterns and Theory—Burgundy Room

T. O. Paine, presiding

Magnetic Domain Patterns on Iron Whiskers. *R. V. Coleman, G. G. Scott,* Research Staff, General Motors Corporation

Domain Observations on Iron Whiskers. *R. W. DeBlois, C. D. Graham, Jr.,* General Electric Research Laboratory

Magnetic Domain Wall Motion. *P. R. Gillette, K. Oshima,* Stanford Research Institute

A Calculation of the Energy Loss in Magnetic Sheet Materials Using a Domain Model. *R. H. Fry, C. P. Bean,* General Electric Research Laboratory

Growth of MnBi Crystals and Evidence for Subgrains from Domain Patterns. *W. C. Ellis, H. J. Williams, R. C. Sherwood,* Bell Telephone Laboratories, Inc.

Antiferromagnetic Domain Walls and the Magnetization Process in α-Fe_2O_3. *I. S. Jacobs, C. P. Bean,* General Electric Research Laboratory

Optical Properties of Several Ferrimagnetic Garnets. *J. F. Dillon, Jr.,* Bell Telephone Laboratories, Inc.

Contribution to the Study of Ferromagnetic Multidomain Particles. *H. Amar,* The Franklin Institute Laboratories, Solid State Division

Constraint Principles in Ferromagnetic Domain Theory. *L. Gold,* Lincoln Laboratory, Massachusetts Institute of Technology

Papers Invited for Computer Conference

The 1958 Western Joint Computer Conference will be held at the Ambassador Hotel in Los Angeles, Calif., May 6-9, it was announced by W. H. Ware, committee chairman. Original papers on subjects pertinent to computer design and application are invited for presentation during the conference. Titles and 200-word abstracts should be submitted before January 15 to Technical Program Chairman, Western Joint Computer Conference, P.O. Box 213, Claremont, Calif.

Cosponsored by the AIEE, Institute of Radio Engineers, and Association for Computing Machinery, the conference will have as its theme "Contrasts in Computers," with panel groups comprised of leading authorities in the field discussing controversial aspects of modern computers.

Officers To Be Nominated for 1958 Institute Election

For the nomination of officers to be voted upon in the Spring of 1958, the AIEE Nominating Committee will meet in New York, N. Y., February 3, 1958. The officers to be elected are: a president, a treasurer, three directors, and six vice-presidents, one from each of the odd-numbered geographical Districts. Fellows only are eligible for the office of president; Members and Fellows for the offices of vice-presidents, directors, and treasurer.

To guide this Committee in performing its constituted task, suggestions from the membership are, of course, highly desirable. To be available for consideration of the Committee, all suggestions must be received by the secretary of the Committee at Institute headquarters not later than December 16, 1957.

In accordance with the provisions in the Constitution (C) and Bylaws (B), quoted in the following paragraphs, actions relating to the organization of the Nominating Committee are now under way:

Constitution

C-30. There shall be constituted each year a Nominating Committee consisting of one representative of each geographical District, elected by its executive committee, one representative of each technical division elected by the division committee, and other members chosen by and from the Board of Directors not exceeding in number the number of technical divisions; all to be selected when and as provided in the Bylaws. The Secretary of the Institute shall be the secretary of the Nominating Committee, without voting power.

C-31. The executive committee of each geographical District shall act as a nominating committee of the candidate for election as vice-president of that District, or for filling a vacancy in such office for an unexpired term whenever a vacancy occurs.

AIEE Booth at WESCON

Courtesy Moulin Studios

THE AIEE BOOTH was exhibited at the Western Electronics Show and Convention (WESCON) held in San Francisco, Calif., August 20-23, 1957. For the first time, AIEE was represented at the show and many favorable compliments were received. To the left is the demonstration of solar energy furnished by courtesy of the Pacific Tel. & Tel. Co. Considerable credit should go to Abe Tilles of the AIEE Electronics Committee, T. P. Galavan and Dick Hatfield, representing *Electrical Engineering* and the Membership Committee of the San Francisco Section, who attended the booth and made the arrangements.

C-32. The Nominating Committee shall receive such suggestions and proposals as any member or group of members may desire to offer, such suggestions being sent to the secretary of the committee.

The Nominating Committee shall name, on or before January 31 of each year, one or more candidates for president, treasurer, and the proper number of directors, and shall include in its ticket such candidates for vice-presidents as have been named by the nominating committees of the respective geographical Districts, if received by the Nominating Committee when and as provided in the Bylaws; otherwise the Nominating Committee shall nominate one or more candidates for vice-president(s) from the District(s) concerned.

Bylaws

B-27. During September of each year, the secretary of the Nominating Committee shall notify the chairman and secretary of the executive committee of each geographical District, and the chairman and secretary of each technical division committee, that, by December 15 of that year, each District and each technical division should select a representative to serve as a member of the AIEE Nominating Committee and an alternate to serve if the representative is unable to attend the meeting of the Nominating Committee. The names of representatives and alternates, so selected, should be transmitted by the above designated officers to the secretary of the Nominating Committee by December 15.

During September of each year, the secretary of the Nominating Committee shall notify the chairman and secretary of the executive committee of each geographical District in which there is, or will be during the year, a vacancy in the office of vice-president that, by December 15 of that year, a nomination for a vice-president in that District made by the District executive committee should be in the hands of the secretary of the Nominating Committee.

Between October 1 and December 15 of each year, the Board of Directors shall choose a number of its members, not exceeding the number of technical divisions, to serve on the Nominating Committee, and notify the secretary of the Nominating Committee of the names of the members so chosen.

The secretary of the Nominating Committee shall give the members so selected not less than 10 days' notice of the first meeting of the committee, which shall be held not later than February 15.* At this meeting, the committee shall elect a chairman and shall proceed to make up a ticket of nominees for the offices to be filled at the next election. To insure that full consideration be given to all suggestions from the general membership, they must be in the hands of the secretary of the committee by December 15. The nominations as made by the Nominating Committee shall be published in the March issue of *Electrical Engineering*, or otherwise mailed to the Institute membership not later than the first week in March.

Independent nominations may be made in accordance with provisions in article VI, C-33, of the Constitution and B-28 of the Bylaws, which are quoted in the following:

Constitution

C-33. Independent nominations may be made by the petition of twenty-five (25) or more corporate members sent to the secretary when and as provided in the Bylaws; such petitions for the nomination of vice-presidents shall be signed only by members within the District concerned.

B-28. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with C-33 (Constitution), must be received by the secretary of the Nominating Committee not later than March 15 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

28.1 The candidates shall appear on the ballot, grouped alphabetically under the name of the office for which each is a candidate. The voting in each case shall be restricted to the nominees printed on the ballot.

28.2 The ballot shall provide a place where the entire slate of nominees can be voted with a single mark, if there is no choice to be made between any of the candidates. The balloting should be secret in the case of a contest. The ballots shall be checked for ineligible voters only in the case of a contest.

28.3 The Tellers' Election Report shall give the sum total of the ballots received and shall designate this total as a vote for the entire slate of officers where there are no alternative candidates. Only in the case of a contest shall an individual count be made.

28.4 The President shall decide the number of Tellers for each election. The Secretary is authorized to prepare the ballot for counting on a business machine where feasible.

(Signed) *N. S. Hibshman*
Secretary

* Adopted subject to pending modification of C-32.

Eastern Joint Computer Conference Program Announced

The 1957 Eastern Joint Computer Conference, sponsored by the AIEE, Institute of Radio Engineers, and Association for Computing Machinery, with participation by the National Simulation Council, will be held December 9-13 at the Shoreham and Sheraton-Park Hotels in Washington, D.C.

The theme of this year's conference will be "Computers with Deadlines To Meet."

In addition to the technical sessions, there will be a large exhibit area devoted to displays of complete data processing and computing systems as well as of computer components and subassemblies.

The tentative technical program for the conference follows.

Monday, December 9

10:00 a.m. Industrial Control Computers and Instrumentation I

Session Chairman: E. C. Johnson, Bendix Aviation Corporation

Real-Time Hybrid Computers for Electronic Control Systems. *C. T. Leondes*, University of California at Los Angeles

System Characteristics of a Computer-Controller for Use in the Process Industries. *W. E. Frady, M. Phister, Jr.*, Ramo-Wooldridge Corporation

A Co-ordinated Data Processing System and Analog Computer To Determine Refinery Process Operating Guides. *C. H. Taylor*, Fisher and Porter Company

Real-Time Presentation of Reduced Wind Tunnel Data. *M. Bain, W. Hoover*, California Institute of Technology Jet Propulsion Laboratory

2:00 p.m. Industrial Control Computers and Instrumentation II

Session Chairman: J. F. Reintjes, Massachusetts Institute of Technology

Mechanization of Letter Mail Sorting. *I. Rotkin*, National Bureau of Standards

The Master Terrain Model System. *J. A. Stieber*, U.S. Naval Training Device Center

Systems Design of a Numerically Controlled Machine Tool. *E. C. Johnson, Y. C. Ho*, Bendix Aviation Corporation

Logical Organization of the Digimatic Computer. *J. Rosenberg*, Electronic Control Systems, Inc.

Logic Functions and Their Application to Steel Mill Control. *W. M. Brittain*, Westinghouse Electric Corporation

6:00 p.m. Cocktail Party

Tuesday, December 10

9:00 a.m. Traffic Control, Navigation, and Surveillance I

Session Chairman: Morris Rubinoff, University of Pennsylvania

Preparations for Tracking an Artificial Earth Satellite at the Vanguard Computer Center. *D. A. Quarles, Jr.*, International Business Machines Corporation

Use of a Digital Computer for Airborne Guidance and Navigation. *S. Zadoff, J. Rattner*, Sperry Gyroscope Company

Experimentation on the Human Operator Tie-In to an Airborne Navigation Computer Control System. *C. A. Bennett*, International Business Machines Corporation

Multiweapon Automatic Target and Battery Evaluator. *A. E. Miller*, Borroughs Corporation

Control of Automobile Traffic as a Problem in Real-Time Computation. *D. L. Gerlough*, University of California

12:15 p.m. Luncheon

2:00 p.m. Simulation in Real Time

Session Chairman: R. M. Howe, University of Michigan

Physical Simulation of Nuclear Reactor Power Plant Systems. *J. J. Stone, B. B. Gordon, R. S. Boyd*, Battelle Memorial Institute

Applications of Computers to Automobile Stability and Control Problems. *R. H. Kohr*, General Motors Corporation

Combined Analog-Digital Simulation of Sampled Data Systems. *H. K. Skramstad, A. A. Ernst, J. P. Nigro*, National Bureau of Standards

Facilities and Instrumentation Required for Real-Time Simulation Involving System Hardware. *A. J. Thiberville*, Convair

Extending Flight Simulator Time Scale. *E. J. McGlinn*, Bendix Aviation Corporation

Analog, Digital, and Combined Analog-Digital Computers for Real-Time Simulation. *W. W. Seifert*, Massachusetts Institute of Technology

Wednesday, December 11

9:00 a.m. Synthesis of Real-Time Systems

Session Chairman: J. W. Carr, III, University of Michigan

The Place of Self-Repairing Facilities in Computers with Deadlines To Meet. *L. Fein*, consultant

Organizing a Network of Computers to Meet Deadlines. *A. L. Leiner, W. A. Notz, J. L. Smith, A. Weinberger*, National Bureau of Standards

A Program Controlled Program Interrupt System. *F. P. Brooks, Jr.*, International Business Machines Corporation

A Transistor Circuit Chassis for High Reliability in Missile Guidance Systems. *G. A. Raymond*, Remington Rand Univac

Small Computer Talks Three Machine Languages without Expensive Buffers. *J. H. Randall*, National Cash Register Company

The Optimum Synthesis of Computer Limited Sampled Data Systems. *A. S. Robinson*, Eclipse-Pioneer Division, Bendix Aviation Corporation

2:00 p.m. Traffic Control, Navigation and Surveillance II

Session Chairman: A. A. Cohen, Remington Rand Univac

A Real-Time Control System for Air Defense. *R. R. Everett, H. D. Bennington, C. A. Zraket*, MIT Lincoln Laboratory

***AN/FST-2* Radar Processing Equipment for SAGE.** *H. W. Taylor, E. W. Veitch, J. Wylen*, Burroughs Corporation

The SAGE Duplex Computers. *C. E. Diss*, International Business Machines Corporation; *P. R. Vance*, MIT Lincoln Laboratory; *L. G. Dooley*, Rand Corporation

The Application of Electronic Computers to Air Traffic Control. *W. H. Thomas*, International Business Machines Corporation

On-Line Data Processing for CAA Air Traffic Control Operations. *G. E. Fenimore*, CAA Technical Development Evaluation Center

6:00 p.m. Hospitality Hour

7:00 p.m. Banquet

Speaker: E. R. Quesada, special assistant to the president for Airways Modernization

Thursday, December 12

9:00 a.m. On-Line Business Systems

Session Chairman: R. E. Sprague, Teleregister Corporation

Design Techniques for Multiple Interconnected On-Line Data Processors. *F. J. Gaffney, S. Levine*, Teleregister Corporation

Reservations Communications Utilizing a General-Purpose Digital Computer. *R. A. McAvoy*, Eastern Airlines

Stock Transaction Records. *A. H. Payne*, Melpar, Inc.

On-Line Sales Recording System. *J. S. Baer, A. S. Rettig, I. Cohen*, Radio Corporation of America

The GE Integrated Bank Data Processing System Model 2B100. *J. Levinthal, J. Weizenbaum, H. Herold*, General Electric Company

12:15 p.m. Luncheon

Speaker: Max Woodbury, New York University, "The Voters Won't Wait!"

2:00 p.m. Digital Communications Techniques

Session Chairman: L. L. Auerbach, Auerbach Electronic Corporation

An Introduction to the Bell System's First Electronic Switching Office. *R. W. Ketchledge*, Bell Telephone Laboratories

Communications Switching Systems as Real-Time Computers. *A. E. Joel*, Bell Telephone Laboratories

Communications between Remotely Located Digital Computers. *F. P. Forbath*, Collins Radio Company

Derivation of Business Machines Data Channels from Standard Telephone Lines for Simultaneous Transmission with Speech. *E. Hopner*, International Business Machines Corporation

Traffic Aspects of Communications Switching Systems. *J. A. Bader*, Bell Telephone Laboratories

A Self-Checking System for High-Speed Transmission of Magnetic Tape Digital Data. *E. J. Casey, G. W. Fritze*, Remington Rand Univac

Friday, December 13

9:00 a.m. Document Reading, Pattern Recognition, and Character Synthesis

Session Chairman: Howard Engstrom, National Security Agency

The Use of an IBM 704 in the Simulation of Speech Recognition Systems. *G. L. Schultz*, International Business Machines Corporation

An Automatic Voice Readout System. *C. W. Poppe, P. Suhr*, Fairchild Controls Corporation

Experimental Use of Electronic Computers in Processing Pictorial Information. *L. Cahn, R. A. Kirsch, L. C. Ray, G. H. Urban*, National Bureau of Standards

Devices for Reading Handwritten Characters. *T. L. Dimond*, Bell Telephone Laboratories

Automatic Registration in High-Speed Character Sensing Equipment. *A. I. Tersoff*, Intelligent Machines Research Corporation

Optical Displays for Data Handling System Output. *J. Ogle*, Burroughs Corporation

The NCR High-Speed Electromagnetic Printer. *J. M. Seehof*, National Cash Register Company

Hoover Medal Awarded to Scott Turner

In recognition of many years of outstanding public service in various capacities, Scott Turner, of New York, N.Y., former director of the United States Bureau of Mines, has been chosen by the representatives of four major national engineering organizations to receive their jointly sponsored Hoover Medal for 1957.

Scott Turner

Named after former President Herbert Hoover, who was its first recipient, in 1930, this gold medal is awarded "by engineers, to a fellow-engineer, for distinguished public service." It is one of the most distinguished honors bestowed by the engineering profession. The sponsors are the AIEE, the American Society of Civil Engineers, the American Institute of Mining, Metallurgical and Petroleum Engineers (AIME), and The American Society of Mechanical Engineers.

Presentation will be in New York in February 1958, at the annual meeting of AIME, of which Mr. Hoover was president in 1920, and which Mr. Turner also headed as president.

Mr. Turner became a member of AIME in 1906 and its president in 1932. He is a member of the Mining and Metallurgical Society of America and the Canadian Institute of Mining and Metallurgy and is an honorary member of the American Zinc Institute and of the Coal Mining Institute of America. He recently served two terms as president of the American Institute of Consulting Engineers.

CHARTER MEMBER E. F. Lopez receives his certificate from Section Chairman Julio Colón at a meeting of the AIEE Mexico Section which recently celebrated its 35th anniversary.

AIEE Mexico Section Celebrates 35th Anniversary

The Mexico Section of the AIEE celebrated its 35th anniversary at its monthly meeting in the American Club, Mexico City, Mexico, on August 30, 1957.

Immediate past chairman G. Solis Payan recalled the sessions of 1922, when a few enthusiastic members gathered in a cantina and technical talks were delivered while having tequila, beer, and sandwiches. Since then, conditions have changed, and the Section now has some 300 members, its own offices with a secretary, typewriters, and telephones.

Certificates were presented by Chairman Julio Colón to Charter Members G. Solis Payan, E. F. Lopez, and Francisco Aubert.

Guest speaker Emilio Leonarz discussed the importance of atomic power and solar energy in Mexico at the present time, when its population is doubling every 16 years and a shortage of oil and coal may be expected by the year 2025.

After dinner, a painting and a radio

were raffled off among the ladies present. H. H. Braun of the American Embassy, Enrique González, president of Camara Nacional de Electricidad, Jorge Boué, director of Instituto de Electricidad were guests of honor at the meeting which 75 members and their wives attended.

Scott Helt Memorial Award Established

An award to be known as the Scott Helt Memorial Award has been established by the administrative committee of the Professional Group on Broadcast Transmission Systems of the Institute of Radio Engineers (IRE). This is the first professional group award and is established in memory of Mr. Helt (M '49) who died on August 9, 1956. It will be awarded annually for the best paper published in the *Transactions* of the Group.

Trustees of Electrical Historical Foundation Meet

The electrical industry's effort to "locate, preserve, and encourage the public display of historical electrial equipment, memorabilia, photographs, and printed matter" moved ahead when the board of trustees of the Electrical Historical Foundation met recently in the Burndy Library, Norwalk, Conn., itself a noted repository of source material on the history of science and technology.

Attending the meeting were F. S. Black, publisher and editor of *Electrical World;* Bern Dibner, director of the Burndy Library; Dr. Erich Hausmann, dean emeritus of the Brooklyn Polytechnic Institute; Dr. S. G. Hibben of the Holophane Corporation; H. E. Kent of the Edison Electric Institute; E. S. Lincoln, consulting electrical engineer; J. K. Sprague, president of Sprague Electric Company, and Dr. C. F. Wagner of the Westinghouse Electric Corporation.

Plans were made to expand the board to make it broadly representative of industry associations, electrical and electronic manufacturers, utilities, educational institutions, museums, and other groups interested in the progress of the industry. Some 10 or 12 places remain to be filled.

Membership classifications were established, with contributions of $1,000 or more for sustaining members, $100 or more for contributing members, and $10 or more for associate members. Sprague, Westinghouse, and the Burndy Library became the first sustaining members with $1,000 contributions.

A sizable percentage of the Foundation's presently limited funds was allocated to continue an existing program of locating and cataloging all historical electrical equipment on exhibit or in storage in museums, educational institutions, industrial plants, public utilities, and elsewhere.

Other objectives of the Foundation are to acquire valuable equipment, particularly that in danger of being lost, and put it in order for display, and to preserve equipment that will become historical in the near future.

Historical publications on electrical subjects will be received and put in proper order; museums and other organizations will be assisted to display electrical equipment for the public and for educational purposes; places for equipment and publications will be found in existing museums and libraries; and plans will be made for such facilities in areas where they do not now exist.

Interest was stimulated by an editorial, "First an Inventory, Then a Museum," in the March 28, 1955, issue of *Electrical World*. Organization of the Electrical Historical Foundation was begun in New York in August 1956 and an indenture of trust, formally incorporating the Foundation, was obtained in May 1957.

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until November 27. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., on or before November 27.

57-225 A Magnetic "De-Ion" Air Breaker for 750 Mva, 13.8 Kv. *Russel Frink, J. M. Kozlovic*

57-548 An Approximate Transient Solution of the Tapered Transmission Line. *L. O. Barthold*

57-606 Transmission System Voltages under Single and Double Line-to-Ground Fault Conditions. *R. W. Johnston*

57-708 Effects of Electron Irradiation on the Electrical Properties of Mylar. *E. L. Brancato, J. G. Allard*

57-911 Surge Protection of Cable-Connected Power Transformers at Scattergood Steam Plant. *C. M. Short, T. J. Bliss, M. K. Enns*

Preprints may be purchased at 40¢ each to members, 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th St., New York 18, N. Y.

Dr. Irving Langmuir, World-Famous Scientist, Dies

Dr. Irving Langmuir, world-famous scientist, died at Falmouth, Mass., on Friday, August 16, 1957. He was 76 years old.

The Nobel Prize scientist often regarded as one of the scientific geniuses of modern times, was on the staff of the General Electric (GE) Research Laboratory from 1909 until his retirement in 1950.

During his long career at GE, Dr. Langmuir's researches were estimated to have saved the American public nearly $1 billion per year in electric light bills, helped establish modern radio and television broadcasting, helped safeguard the lives of soldiers in battle, and, more recently, provided man with a key to possible control of the weather.

His contributions to pure scientific knowledge are considered of highest importance. His studies on electron emission and on gaseous discharges are regarded as classics. His experimentation with oil films on water uncovered an entirely new branch of chemistry, known as two dimensional or surface chemistry. Here phenomena are found to be entirely different from any known before. Experimental techniques that he developed for studying proteins furnished a new and powerful attack on fundamental problems of the functions of the human organism and are now being used by biochemists and biophysicists throughout the world.

For his accomplishments, Dr. Langmuir received the world's top-ranking scientific awards, including the Nobel Prize in chemistry, granted to him in 1932. Both a chemist and a physicist, he was once described as one "who continually embarks upon mental voyages in regions so nearly airless that only the mind can breathe in comfort."

DR. IRVING LANGMUIR, world-famous scientist, who died recently at the age of 76.

It was on such "voyages" that he developed the gas-filled incandescent lamp, the high-vacuum power tube, atomic hydrogen welding, a highly efficient screening-smoke generator for the military, and methods for artificial production of snow and rain from the clouds.

Among other major scientific accomplishments of Dr. Langmuir were the condensation mercury-vapor pump for producing very high vacuum and a series of highly effective submarine detectors used in World War I, which he developed in collaboration with Dr. W. D. Coolidge, retired vice-president and director of research for GE.

As an outgrowth of his study of oil films on water, Dr. Langmuir devised a means for optically detecting viruses, toxins, poisons, and other tiny and invisible materials. This method has proved highly useful in biology and toxicology.

Dr. Langmuir was a foreign member of the Royal Society of London and a Fellow of the American Physical Society. He had served as president of the American Chemical Society, and as president of the American Association for the Advancement of Science. Other organizations of which he was a member include the Academy of Arts and Sciences, Upsala; Tau Beta Pi, Phi Lambda Upsilon; and Sigma Xi.

An honorary member of several societies, including the Chemical Society of London, Dr. Langmuir held honorary degrees from the following colleges and universities: Northwestern, Union, Edinburgh (Scotland), Columbia, Kenyon, Princeton, Lehigh, Harvard, Oxford, Johns Hopkins, Rutgers, Queens (Canada), and Stevens Institute of Technology.

COMMITTEE ACTIVITIES

EDITOR'S NOTE: *This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.*

Communication Division

Radio Communications Systems Committee (R. D. Campbell, *Chairman;* David Talley, *Vice-Chairman;* P. T. Sproul, *Secretary*). The Radio Communications Systems Committee has completed another year of its activities and is looking ahead to the possibilities of providing material of interest and significance in this field during the coming year for the benefit of the AIEE membership. Increasing interest has been indicated in the work of the Committee during the past year with the result that it has been possible to obtain more and better papers for presentation at the Institute meetings.

The Committee is now planning a joint technical session with the Telvision and Aural Broadcasting Systems Committee featuring beyond-the-horizon or scatter systems for the Winter General Meeting. Also, at the Fall General Meeting the Committee sponsored a technical session which included a description of the new main route microwave system under development for use in the telephone network of the United States. This system will be used for television, telephone, and other forms of public communication services.

The Committee believes that the main interest of the membership lies in the broad field of systems design and operation as contrasted to the details involved in the design and manufacture of component parts. This is believed to be in line with the purpose of the Committee, the title of which contains the words "Radio Communications Systems."

General Applications Division

Domestic and Commercial Applications Committee (G. E. Schall, Jr., *Chairman;* B. F. Parr, *Vice-Chairman;* W. R. Crawford, *Secretary*). The Domestic and Commercial Applications Committee, through its Electric Space Heating and Heat Pump Subcommittee (East) plans to present an interesting group of papers dealing with heat pumps and electric heating at the coming session during the 1958 Winter General Meeting in New York, N.Y.

Among the papers scheduled are included topics which will cover a comparison of heat pump and resistance cable heating in the same residence in the Northeast, a discussion of resistance heating in residential locations in the Midwest, and also presentations dealing with heat pump applications in the South, and the operation of compound type heat pump units in large building installations.

The Electric Space Heating and Heat Pump Subcommittee (West) recently concluded a successful session at Pasco, Wash., during which time the Committee outlined topics for next year's Pacific Coast session which will be broadened to cover, in addition to heating and heat pumps, other items of general interest relating to the application of electric power in homes and industry.

Industry Division

Electric Heating Committee (F. T. Chesnut, *Chairman;* C. A. Tudbury, *Vice-Chairman;* E. J. Bates, *Secretary*). The Electric Heating Committee, in conjunction with its Induction and Dielectric Heating, Radiant Heating and Technical Data Subcommittees, sponsored another of its biennial Electric Heating Conferences in Toledo, Ohio, April 23-24, 1957. Some 18 papers were scheduled and the meeting was well attended. Bound copies of the papers are available at AIEE Headquarters.

It is contemplated that the next such conference will be held in the Spring of 1959 and plans are expected to be launched at a meeting of the main Committee to be held during the Winter General Meeting in New York, N.Y. The Committee would appreciate receiving suggestions for papers to be considered.

Power Division

Power Generation Committee (J. H. Kinghorn, *Chairman;* C. F. Paulus, *Vice-Chairman;* L. A. Kilgore, *Secretary*). The work of the Joint AIEE-American Society of Mechanical Engineers Recommended Specifications for Speed Governing of Prime Movers Committee has reached a point where an entirely new specification has been drawn up for internal combustion engine-generator units and approved by the Committee. A full-scale revision of a similar existing specification for steam turbine drives has been made and was presented at the 1957 Fall General Meeting for discussion. It is expected that this revision can be put in final shape for adoption in the near future. Work is being started on a similar specification for gas turbines.

As a result of a number of individual papers and discussions, the Excitation Systems Subcommittee is preparing its recommendations for excitation system definitions and will present them at a technical session in the near future. This represents an area where no adequate definitions now exist and where much present confusion can be cleared up by their formulation.

The Prime Movers Control and Protection Subcommittee has prepared a preliminary report on generator protection as a part of its investigation into integrated protection of generating units. In furthering this project, a panel session at the 1957 Fall General Meeting explored the relation of automatic transfer of steam station auxiliaries to station protection. It is expected that this will furnish background information for the next step in the Subcommittee's project.

Protective Devices Committee (E. M. Hunter, *Chairman;* A. M. Opsahl, *Vice-Chairman;* W. S. Price, *Secretary*). A joint session of the Insulated Conductor and Protective Devices Committees on the application and operating experiences with Aerial Cable was held at the Montreal, Que., meeting in June. Plans are being completed to have the several papers presented published in a common binder for ready reference.

The working group on the revision of AIEE Standard No. 32 has included in its activity the determination of short time temperature limits for neutral grounding devices. Another area of consideration has been the definition of Coefficient of Grounding. A draft of the revised standard will be ready in the near future.

A working group has been formed to revise and bring up to date AIEE Report No. 954—Application Guides for Ground-Fault Neutralizers, Grounding of Generators, and Grounding of Transmission Systems. The objectives of this activity are:

(1) To review the present guides, and define areas of controversy and determine the scope of what action should be taken.

(2) To assign areas requiring revision to other working groups before any revision is undertaken.

The Working Group on Protection of Multiline Substations is considering the evaluation of nonstandard wave shapes on insulation. Also being studied are standard forms of substation layouts with a view toward reducing the number of variables to be considered in the project.

The working group on arrester characteristics was recently formed to assem-

ble, co-ordinate, and maintain in a readily available form the performance characteristics of lightning arresters. From time to time, as the arrester characteristics change, the data will be published in Transactions papers. From now on, this will be a continuing activity of the Protective Devices Committee so that up-to-date arrester characteristics will be available to the industry.

Substations Committee (W. S. Scheering, *Chairman;* J. A. Smith, *Vice-Chairman;* A. F. Sedgwick, *Secretary*). Ten working groups under this Committee have been assigned various projects for study. The Working Group on Fire Protection and Minimizing Fire Hazards in Substations has completed its work and presented a report (*CP57-925*) at a technical session sponsored by the Committee at the Pacific General Meeting held at Pasco, Wash. in August.

The Working Group on Design and Utilization of Mobile Substations has completed its investigations and these will be presented in a report "Mobile Substations—Their Use, and the Design of Distribution Substations to Facilitate Their Use" at a technical session during the 1958 Winter General Meeting in New York, N.Y.

The other working groups are actively engaged in studies and investigations of their subects and it is expected that reports will be presented at technical sessions during future general meetings of the Institute.

Liaison representation is being maintained by this Committee with the Standards Committee and with working groups under the Transmission and Distribution Committee and the Telemetering Committee. Liaison representatives from the Transmission and Distribution Committee, the Protective Devices Committee, and the Ground Resistance and Potential Gradient Measurements Subcommittee have been assigned to working groups under the Substations Committee.

System Engineering Committee (R. T. Purdy, *Chairman;* C. N. Metcalf, *Vice-Chairman;* A. P. Fugill, *Secretary*). Initial steps have been taken by the Computer Application Subcommittee to assist the Computing Devices Committee in the organization of a proposed Special Technical Conference on Computer Application. A two- or three-day Conference on Computers in the Electric Power Industry is proposed. One day might be devoted to the use of these computers by manufacturers of electrical equipment in the design and fabrication of that equipment. The second day would be used for applications by electric utility companies in their engineering problems of planning, design, and operation. Some part of the program might touch upon customer billing or other accounting operations now being performed on the various computers. It is not intended that the design of computers themselves or their components be included in this special technical conference as those areas are adequately handled elsewhere.

The System Controls Subcommittee has completed its efforts to bring into focus its study on the application of incremental heat rates to automatic dispatching equipment. Further efforts are under way to develop a program on the control of reactive power.

For the 1958 Winter General Meeting, the field of system economics will be featured by papers on loss minimization, valve point loading of steam turbines, operating experience with various dispatch computer systems and their effect on system economics. For the 1958 Summer General Meeting, the co-ordinated economic operation of steam-hydro and all-hydro systems will be featured. The possible sponsorship of a session on new techniques developed by operations research is under review.

The Arc Furnace Working Group of the System Planning Subcommittee has been given a leave of absence with appreciation for its extended study and report. Future questions to be answered by a Working Group are: (1) What is the cyclic flicker effect of furnaces in excess of 25 mva? (2) What are the characteristics of suppressed arc or continuous melt arc furnaces?

It is felt that at present no further study should be made of arc furnace operation in view of the small number of these larger furnaces in use.

The Application of Probability Methods Subcommittee has in the past been instrumental in the publication in the Transactions of Forced Outage Data on Turbines and Boilers. This was collected by the Edison Electric Institute (EEI). The EEI Outage Data on Turbines and Boilers has been discontinued in prior form and a new questionnaire is in use on an experimental basis. The Subcommittee feels that the collection of outage data should be continued on turbines and boilers and should be extended further to include transformers, transmission lines, and distribution systems. The Subcommittee is considering the organization of a symposium to show how various companies apply probability methods to their problems.

Science and Electronics Division

Basic Sciences Committee (W. C. Dunlap, *Chairman;* J. E. Goldman, *Vice-Chairman,* W. D. Rowe, *Secretary*). A meeting of this Committee was held at the Summer General Meeting at Montreal, Que., Canada. The vice-chairman (and incoming chairman) presided since illness prevented the attendance of the chairman, W. R. LePage.

The Committee during the last year inaugurated a program, with some success, of providing speakers on basic sciences topics to local Sections requesting them. Although specific invitations will be sent out separately to local chairmen, this occasion may also be taken by local chairmen or program chairmen to indicate their interest by letter to the Committee, indicating the topics in which they are interested, suitable dates, and whether or not expenses can be paid for the speaker. Final negotiations are left to the local chairman and the speaker.

In addition to its regular activities in reviewing papers and scheduling session programs, the Basic Sciences Committee is intensifying its efforts to increase the number of papers on basic sciences topics for *Electrical Engineering*. This series of elementary and review papers will include subects appealing, it is hoped, both to students and to practicing engineers anxious to keep up with modern developments.

Among the activities of the Basic Sciences Committee is the stimulation through its Basic Concepts and other Subcommittees of discussions dealing with the nature and use of the fundamental concepts of electrical science. This activity has long led to some of the liveliest, not to say controversial, activities of the Committee, inasmuch as many of the fundamental concepts are difficult to understand clearly, and it is easy for misunderstandings to arise. Among such discussions is one dealing with the mode of operation of single-phase induction motors, in which one party to the discussions has been Edward Bretch of St. Louis, who has been interested for many years in clarifying the nature of the operation of this machine, and in particular, satisfying himself as to the possibility of resolving a magnetic flux into two rotating fluxes moving in opposite directions. In such discussions, the Basic Sciences Committee, and its Subcommittees attempt to provide forums, through session programs, and by means of papers submitted to the technical journals, for the clarification of the issues. It makes no attempt, however, and none of its activities are intended, to proclaim "correct" or "official" attitudes of the Institute on questions of basic concepts. The final judgment on these matters has always rested, and will continue to rest, in the judgments, opinions, and writings of the competent and expert workers in the various fields concerned.

AIEE PERSONALITIES

T. C. Fry (F '50), consulting engineer, has been appointed vice president and director of Univac engineering for the Remington Rand Division of Sperry Rand Corporation. Dr. Fry was Formerly assistant to the president of Bell Telephone Laboratories. Since leaving the Bell System in 1956, he has been a consultant to The International Telephone and Telegraph Corporation and Remington Rand. Dr. Fry is a fellow of the American Physical Society and the Institute of Mathematical Statistics. He has been a vice-president of the American Mathematical Society and of the Mathematical Association of America.

R. H. Mertz (AM '22, M '41, Member for Life), electrical apparatus engineer for The Detroit Edison Company, retired

Bimonthly Publications

The bimonthly publications, *Communication and Electronics, Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

August 1 after 41 years of service with the company. Mr. Mertz has served on the AIEE Protective Devices Committee (1951-53).

G. O. Calabrese (AM '25, M '40, F '51), professor of electrical engineering, New York University, has joined the Particle Accelerator Division of Argonne National Laboratory. Born in Oliveri, Italy, he attended the Polytechnic Institute of Turin, Italy, where he received his Ph.D. in engineering in 1921. Dr. Calabrese also attended Columbia University where he did postgraduate work in mathematics. He has served on the following AIEE Committees: Power Generation (1948-57) and Board of Examiners (1956-57).

H. N. Muller (AM '37, F '49), chief engineer, Canadian Westinghouse Company, Ltd., was elected a vice-president at a meeting of the board of directors held in Hamilton, Ont., Canada. An active member of the Institute, Mr. Muller has served on the following AIEE Committees: Power Generation (1944-46); Membership (1948-50); Education (1947-53), chairman 1950-52); Award of Institute Prizes (1948-49); Professional Division Advisory (1948-52); Student Branches (1948-54), chairman 1948-49); Charles LeGeyt Fortescue Fellowship Committee (1947-50, chairman 1949-50); Publications (1952-57); and Members-for-Life Fund (1954-57).

Ruben Kazarian (AM '40, M '56), assistant engineering manager at the Tocco Division of the Ohio Crankshaft Company, has joined the engineering department of Avtron Manufacturing, Inc., as project engineer.

A. J. Warner (M '45), chief engineer of the Rectifier Division of Standard Telephones and Cables, a division of International Telephone & Telegraph Company, has been appointed director of research for Mycalex Corporation of America and associated companies. Mr. Warner has served on the following AIEE Committees: Special Communication Applications (1949-51) and Insulated Conductors (1951-54).

E. N. Dingley, Jr. (M '56), chief communications engineer of the National Security Agency has retired after more than 27 years of Federal service and has accepted appointment as a staff research engineer with Electronic Communication, Inc. (formerly Air Associates) in St. Petersburg, Fla.

C. H. Eisenhardt (AM '51), Cleveland District sales manager, American Steel and Wire Division, United States Steel Corporation, has been appointed eastern area manager of sales.

T. F. Perkinson (M '46), manager of transportation for the General Electric Company in Schenectady, N. Y., has been elected a Fellow of The American Society of Mechanical Engineers.

H. G. Zambell (AM '38, M '47), engineer-in-charge of development, Pittsburgh (Pa.) Works, Allis-Chalmers Manufacturing Company, has been appointed engineer-in-charge of test and development at Allis-Chalmers Terre Haute (Ind.) Works.

S. C. Killian (AM '42, M'46), assistant general manager, Delta-Star Electric Division, H. K. Porter Company, Inc., has been named a vice-president of Delta-Star.

G. J. Murphy (AM '50), assistant professor of electrical engineering, University of Minnesota, and research consultant with the Minneapolis-Honeywell Regulator Co., has been appointed associate professor of electrical engineering at the Northwestern University Technological Institute.

OBITUARIES

John William Bennett (AM '26, M '29, F '55), chief engineer, Western Massachusetts Electric Company, Springfield, Mass., died recently. Mr. Bennett was born in Marysville, Minn., on October 17, 1897. He was a graduate of the University of Minnesota. From 1919 to 1924, he did miscellaneous work for a number of employers including installation of private lighting plants in theaters, hotels, residences, supervision of commercial and industrial wiring installations, planning and supervising installation of electrically driven pumping machinery. He joined the Central Hudson Gas and Electric Company in 1924 as commercial engineer. From 1925 to 1930, he was distribution engineer for the Eastern New Jersey Power Company, now a part of Jersey Central Power and Light Company. From 1930 to 1937, he did engineering underground distribution work for western Massachusetts companies. In 1937, he became assistant chief engineer for the Western Massachusetts Electric Company, becoming chief engineer in 1944. Mr. Bennett was a Fellow of the American Association for the Advancement of Science. He had been secretary of the AIEE North Eastern District No. 12. Mr. Bennett served as a member of the Admission and Advancement Department, 1956-57, and the Sections Committee, 1956-57.

J. W. Bennett

Herbert Fred Hemker (AM '43, M '52), utility sales engineer, General Electric Company, Memphis, Tenn., died recently. Mr. Hemker was born in Great Bend, Kans., in 1901. He received a B.S. degree in M.E. from Kansas State College. Upon graduation in 1923, he joined the General Electric Company. After assignments in Schenectady, N. Y., and Chicago, Ill., he transferred to Kansas City in 1926 and served there until 1932. He then left the company and returned in 1942 to the Memphis Apparatus Sales Office where in 1948 he was named manager. Mr. Hemker was very active in the Memphis Section of AIEE and was a member of the Tennessee Society of Professional Engineers. He was also active in Boy Scout work.

C. Vinnedge Poling (AM '27, M '41), electrical engineer, Tennessee Valley Authority, Knoxville, Tenn., died recently at the age of 59. Mr. Poling was born in Trenton, Ohio, on June 17, 1898. He was graduated from Ohio State University with a B.S. degree in E.E. in 1924 and entered the General Electric Company Test Course upon graduation. From 1925 to 1937, he was associated in various electrical engineering capacities with several firms including Commonwealth Power Corporation, Jackson, Mich.; Coyne Electric School, Chicago, Ill.; Tallassee Power Company, Alcoa, Tenn.; Frigidaire Corporation, Dayton, Ohio; Western Electric Company, Chicago, Ill.; and Miami Coated Paper Company, Franklin, Ohio. He spent 20 years in a responsible capacity in the Electrical Design Branch of the Tennessee Valley Authority. Mr. Poling was a registered professional engineer in the State of Tennessee.

Elmer Ray Prag (M '46), manufacturer's representative for the Oklahoma City area, Day-Brite Lighting Company, Inc., died recently. Mr. Prag was born in Kingfisher County, Okla., January 1, 1907. He received a bachelor's degree in electrical engineering from the University of Oklahoma in 1931, and was elected a member of Sigma Tau and Tau Beta Pi at that time. In 1937, he received a B.S. degree in education from Central State Teachers College in Edmond, Okla. He taught school in Oklahoma City until 1942. He

(*Continued on page 1015*)

AIEE Section and Student Branch Meetings 1956-57

Table I. Section Membership, August 1957; Section Meetings During Year Ending April 30, 1957

Section	AIEE Members August 1957	Number of Meetings	Total Number of Meetings
Akron	223	7	
Group: Power		3	10
Alabama	314	10	
Subsection: Montgomery		8	18
Arizona	306	9	
Groups: Electronic and Communication		5	
Mining and Industrial		1	
Power		9	24
Arkansas	155	10	
Group: Technical		6	
Subsection: Northwest Arkansas		9	25
Arrowhead	76	9	
Groups: Power Technical Discussion		4	
Industry Discussion		2	15
Baton Rouge	92	11	11
Beaumont	125	13	
Subsection: Lake Charles		5	18
Boston	1,129	8	
Group: Technical		20	28
Canton	115	10	
Groups: Management Discussion		4	
Industrial Application Discussion		1	
Power Generation Discussion		4	19
Central Illinois	209	9	9
Central Indiana	380	9	9
Chicago	2,192	8	
Groups: Basic Science		3	
Communication		4	
Electronics		5	
Industrial		4	
Power		5	29
Cincinnati	388	9	9
Cleveland	1,100	10	
Groups: Basic Sciences		4	
Analog Computer		1	
Digital Computer		4	
Electrical Construction		4	
Electronics-Communication-Instrumentation		4	
Management		3	
Motors and Control		4	
Power Generation and Distribution		4	
Joint Meetings: Section and Management		1	39
Columbus	289	11	
Group: Management Discussion		11	
Subsections: Chillicothe		9	
Zanesville		12	43
Connecticut	871	8	
Group: Technical		17	
Subsection: New London			25
Corpus Christi	118	12	12
Dayton	347	8	
Groups: Aeronautics Discussion		2	
Electronics Discussion		3	
Motors and Control Discussion		3	
Nucleonics Discussion		5	
Power Discussion		3	24
Delaware Bay	181	8	8
Denver	504	10	
Groups: Aeronautical Technical		2	
Communications and Electronics Technical		3	
Electrical Equipment Technical		5	
Power Systems Technical		4	
Subsection: Black Hills		6	
Joint Meetings: Aeronautical Technical-Communications and Electronics Technical-Electrical Equipment Technical-Power Systems Technical and Denver Section		1	31
East Tennessee	442	24	
Subsections: Huntsville		9	
Muscle Shoals		10	
Tullahoma		9	52
El Paso	142	12	12
Erie	238	18	18
Fort Wayne	233	8	
Group: Rotating Machinery Technical Discussion		1	
Subsection: Marion		4	
Joint Meetings: Section and Marion Subsection		1	14
Georgia	411	11	11
Hamilton	223	12	
Subsections: London		6	
Guelph		3	21
Hawaiian	106	12	12
Houston	407	9	
Groups: Communications		1	
Industrial Applications		6	
Power		2	
Subsection: Freeport		5	
Joint Meetings: Section and Freeport Subsection		1	24
Illinois Valley	86	10	
Group: Technical		6	16
Iowa	224	8	
Subsections: Cedar Valley		7	
Northwest Iowa		4	19
Iowa-Illinois	108	8	8
Ithaca	316	7	
Groups: Technical Discussion		7	
Binghamton Area Technical Discussion		3	
Subsection: Binghamton Area		6	
Joint Meetings: Section and Binghamton Area Subsection		1	24
Jacksonville	122	9	9
Johnstown	70	12	
Groups: Electronics and Communications Technical		3	
Industrial Applications Technical		2	
Power Systems Technical		3	20
Kansas City	436	12	
Groups: Communications		5	
Petroleum Technical		1	
Power Technical		5	23
Lehigh Valley	461	10	
Group: Technical Discussion		30	40
Lima	118	8	
Groups: Aeronautical Discussion		3	
Motors and Controls Discussion		2	
Joint Meetings: Section and Aeronautical Discussion		1	
Section and Motor and Control Discussion		1	15
Los Angeles	2,637	7	
Groups: Aviation Division		7	
Basic Sciences		8	
Communications		6	
Electronics		5	
Industry and Construction		8	
Magnetics Committee		5	
Management		7	
Power		6	
Young Engineers Division		8	
Subsections: Boulder City		8	
Riverside-San Bernardino		8	
Joint Meetings: Basic Sciences, Communications and Electronics Division		1	
Basic Science and Electronic Division		1	
Communication Division and Young Engineers Division		1	86
Louisville	219	14	
Group: Technical Discussion		5	
Subsections: Lexington		7	
Paducah		1	27
Lynn	324	21	
Subsection: Merrimack Valley		6	27
Madison	115	11	11
Maine	98	5	
Group: Augusta Power Technical		7	12
Mansfield	124	8	8
Maryland	943	10	
Groups: Aircraft Technical		3	
Automatic Control Technical		2	
Communications Technical		3	
Electronics Technical		3	
Power Technical		3	
Management Technical		3	
Subsection: Eastern Shore		8	35
Memphis	153	10	10
Mexico	173		
Subsection: Monterey			
Miami	224	12	
Group: Grounding Technical		1	13
Michigan	1,114	6	
Groups: Communications Committee		3	
Industry Committee		3	
Management Committee		6	
Power		8	
Science and Electronics Committee		3	29
Milwaukee	995	1	
Groups: Basic Science Discussion		3	
Electronics Discussion		2	
Electrical Machinery Discussion		4	
Power Application and Control Discussion		2	
Transmission and Distribution Discussion		4	
Subsections: Fox River Valley		9	
Racine-Kenosha			
Joint Meetings: Section and Fox River Valley Subsection		1	26
Minnesota	506	9	
Group: Technical		11	
Subsection: Red River Valley		10	30
Mississippi	97	7	7
Mobile-Pensacola	137	11	11
Montana	123	14	
Subsections: Billings		14	
Helena		7	35
Montreal	518	10	
Subsection: Quebec		10	20
Nashville	104	8	8
Nebraska	212	10	
Group: Technical		5	15
New Hampshire	156	8	
Group: Technical		5	13
New Orleans	265	9	
Group: Technical		6	15
New York	6,018		
Groups: Basic Sciences		2	
Communication		9	
Illumination		4	
Power and Industrial		14	
Transportation		7	
Subsections: Hudson Valley Division		7	
New Jersey Division		11	
Joint Meetings: Basic Science and Communication		2	
Power and Industrial and Hudson Valley Division		1	
Power and Industrial and Transportation		1	58
Niagara Frontier	384	7	
Group: Technical		4	11
Niagara International	132	15	

Section	AIEE Members August 1957	Number of Meetings	Total Number of Meetings
Group: Technical	1		16
North Carolina	481	1	
Subsections: Charlotte		9	
Eastern North Carolina		9	
Western North Carolina		9	
Mid-State		9	37
North Texas	700	9	
Groups: Aircraft Technical		1	
Industry Division Technical		4	
Science and Electronic Technical		2	
Instrumentation Technical		1	
Technical Discussion		5	
Subsections: Central Texas		6	
Fort Worth		4	
West Central Texas		10	
Joint Meetings: Fort Worth Subsection and Aircraft Electrical Technical	1		43
Northeastern Michigan	142	12	12
Northern New Mexico	209	12	
Subsection: Los Alamos-Santa Fe	6		18
Oak Ridge	70	10	
Group: Technical Discussion	4		14
Ohio Valley	79	18	
Subsection: Scioto Valley	9		27
Oklahoma City	219	9	
Groups: Electronics-Communications Technical Discussion		7	
Industrial Practices Technical Discussion		6	
Power Systems Technical Discussion	8		30
Ottawa	106	20	20
Panhandle Plains	141	9	
Group: Technical	3		12
Philadelphia	2,065	14	
Groups: Communications Technical		3	
Power and Applications Technical		10	
Science and Electronics and Instrumentation Technical		10	
Subsection: Atlantic City Division		8	
Joint Meetings: Section and Communications Technical	1		46
Pittsburgh	1,578	28	
Subsection: Centre County	7		35
Pittsfield	385	12	
Subsection: Vermont	5		17
Portland	531	17	
Subsections: Eugene		8	
Medford	9		34
Providence	239	10	
Group: Electronics Technical	3		
Joint Meetings: Providence Section and Electronics Technical	1		14
Richland	107	7	
Groups: Hydro-Electric Technical	1		
Industrial Power Systems Technical		9	
Instrument and Electronics Technical	3		
Power Use and Distribution Technical		6	
Utility Technical	2		28
Ridgway	60	8	8
Rochester	300	15	
Group: Technical Discussion Meeting	3		18
Rock River Valley	136	8	8
Sacramento	146	12	
Groups: Design and Construction Technical		6	
Electronics Technical		11	
Transmission and Distribution Technical	6		35
St. Louis	780	11	
Groups: Industrial Apparatus Discussion		8	
Power Practices Discussion		7	
Subsection: Eastern Division		8	
Joint Meetings: Power Practices and Industrial Apparatus Discussion	1		35
San Diego	246	10	
Groups: Aviation Technical		8	
Electronics Technical		7	
Management Development		3	
Utility Technical		8	
Industrial Technical	9		45
St. Maurice Valley	56	9	9
San Francisco	1,743	19	
Groups: Communicatiins		8	
General Applications		2	
Industry		5	
Power		5	
Science and Electronics		6	
Subsections: Fresno		6	
Reno		8	
San Jose		7	
Shasta		8	
Joint Meetings: Section and San Jose Subsection		1	
Section and Communication	1		79
Savannah	55	9	9
Schenectady	1,009	15	
Subsection: Adirondack	6		21
Seattle	792	7	
Groups: Aircraft Technical		9	
Basic Sciences Technical		4	
Industry Technical		3	
Power Technical		4	
Management Technical		1	
Electronics Technical		1	
Subsection: Tacoma		9	
Joint Meetings: Seattle Section and Management Technical		1	
Seattle Section and Tacoma Subsection		1	
Seattle Section and Power Technical		1	
Seattle Section and Power Technical	1		42
Sharon	247	11	11
Shreveport	176	9	
Groups: Communications and Electronics Technical		2	
Industrial Practices Technical Discussion		4	
Transmission and Distribution Technical		2	
Subsection: Monroe		10	
Joint Meetings: Section and Communications and Electronics	1		
Section and Monroe Subsection	1		29
South Bend	134	10	
Groups: Technical	6		16
South Carolina	223	1	
Subsections: Central Savannah River		9	
Charleston		10	
Columbia		11	
Piedmont	10		41
South Texas	132	14	14
Spokane	192	12	
Groups: Electronics Technical		4	
Nuclear Power Technical		9	
Subsection: Wenatchee	9		34
Springfield	129	9	
Group: Technical	4		13
Susquehanna	139	9	9
Syracuse	470	9	
Group: Power		2	
Subsection: St. Lawrence-International	6		17
Tampa	307	8	8
Toledo	187	15	
Groups: Electronic Technical		2	
Industrial Electronics Technical		1	
Industrial Practices Technical		4	
Power Technical	1		23
Toronto	754	15	
Groups: Communications		2	
Discussion		12	
Joint Meetings: Section and Discussion		1	
Section and Communications	1		31
Tulsa	219	11	
Group: Technical	16		27
Utah	128	8	
Subsection: Boise		6	
Eastern Idaho	11		25
Vancouver	279	10	
Groups: Discussion		8	
Technical Discussion Group on Power System	2		20
Victoria	84	12	12
Virginia	328	3	
Subsections: Blue Ridge		5	
Hampton Roads		8	
Richmond	7		23
Virginia Mountain	218	8	8
Washington	1,015	11	11
West Michigan	119	8	8
West Virginia	131	9	
Groups: Electronics and Communications		1	
Power and Distribution	6		16
Wichita	138	13	13
Worcester	125	8	8
	47,344		2,380

Total Sections, 110
Total Technical Groups, 150
Total Subsections, 66

Table II. Branch Meetings Held During Year Ending April 30, 1957

Branch	Number of Meetings
*Akron, University of	9
Alabama Polytechnic Institute	13
*Alabama, University of	10
†Alaska, University of	8
*Alberta, University of	8
*Arizona, University of	5
*Arkansas, University of	10
†Bradford Durfee Technical Institute	7
*British Columbia, University of	23
*Brooklyn, Polytechnic Institute of	
Day Division	22
Evening Division	7
*Brown University	4
*Bucknell University	7
†Buffalo, University of	3
*California Institute of Technology	10
†California State Polytechnic	5
*California, University of	15

Branch	Number of Meetings
*Carnegie Institute of Technology	5
Case Institute of Technology	10
Catholic University of America	2
*Cincinnati, University of	8
*Clarkson College of Technology	
*Clemson A & M College	11
*Colorado A & M College	11
*Colorado, University of	10
*Columbia University	8
*Connecticut, University of	3
*Cooper Union	9
*Cornell University	6
*Dayton, University of	26
*Delaware, University of	8
*Denver, University of	22
*Detroit, University of	5
*Drexel Institute of Technology	8
Duke University	7
Fenn College	12
*Florida, University of	12
†Gannon College	7
*George Washington University	6
Georgia Institute of Technology	13
†Houston, University of	11
*Howard University	7
Idaho, University of	11
Illinois Institute of Technology	6
*Illinois, University of	8
Chicago Division	4
*Iowa State College	10
Iowa, University of	13
*Johns Hopkins University	13
Kansas State College	9
*Kansas, University of	8
Kentucky, University of	11
*Lafayette College	7
†Lamar State College of Technology	12
Laval University	9
*Lehigh University	6
*Louisiana Polytechnic Institute	9
*Louisiana State University	9
*Louisville, University of	11
*Maine, University of	7
*Manhattan College	15
*Marquette University	6
*Maryland, University of	5
*Massachusetts Institute of Technology	2
*Massachusetts, University of	7
†Miami, University of	5
*Michigan College of Mining and Technology	5
*Michigan State University	13
*Michigan, University of	9
Milwaukee School of Engineering	11
*Minnesota, University of	5
Mississippi State College	13
*Missouri School of Mines and Metallurgy	8
*Missouri, University of	5
*Montana State College	8
*Nebraska, University of	8
*Nevada, University of	8
Newark College of Engineering	10
†New Bedford Institute of Technology	7
*New Hampshire, University of	3
*New Mexico College of A & M Arts	6
*New Mexico, University of	
*New York, College of the City of	26
*New York University Day Division	9
Evening Division	5
*North Carolina State College	9
*North Dakota State College	8
*North Dakota, University of	8
*Northeastern University	17
*Northwestern University	27
*Norwich University	4
*Notre Dame, University of	12
Ohio Northern University	6
*Ohio State University	12
*Ohio University	9
*Oklahoma A & M College	8
*Oklahoma, University of	7
Oregon State College	10
*Pennsylvania State University	8
*Pennsylvania, University of	19
Pittsburgh, University of	21
*Pratt Institute	13
*Princeton University	7
Puerto Rico, University of	
*Purdue University	7
*Rensselaer Polytechnic Institute	7
*Rhode Island, University of	9
*Rice Institute	6
*Rose Polytechnic Institute	8
*Rutgers University	8
St. Louis University	4
*Santa Clara, University of	10
†Seattle University	5
*South Carolina, University of	14
South Dakota School of Mines and Technology	12
*South Dakota State College	15
*Southern California, University of	13
*Southern Methodist University	11
*Stanford University	13
*Stevens Institute of Technology	1
*Swarthmore College	5
*Syracuse University	3
†Tennessee Polytechnic Institute	13
Tennessee, University of	12
*Texas, A & M College of	12
†Texas College of Arts and Industries	10
*Texas Technological College	13
*Texas, University of	6
Texas Western College	6
*Toledo, University of	13
*Toronto, University of	5
*Tufts College	5
*Tulane University	5
*Union College	6
United States Naval Academy	1
United State Naval Postgraduate School	6
*Utah, University of	20
Vanderbilt University	11
*Vermont, University of	4
*Villanova University	14
Virginia Military Institute	7
*Virginia Polytechnic Institute	10
*Virginia, University of	6
*Washington, State College of	8
*Washington, University of	9
*Washington University	
*Wayne University	6
*West Virginia University	3
*Wisconsin, University of	8
*Worcester Polytechnic Institute	7
*Wyoming, University of	12
*Yale University	7
Youngstown University	6

Total Branches 152
*Joint AIEE-IRE Branches 110
†Affiliate Branches 12

(*Continued from page 1012*)

had served as chief engineer for the Carson Machine and Supply Company in Oklahoma City and also had worked for the Cincinnati Gas & Electric Company and Douglas Aircraft Company. Mr. Prag was a member of the Illuminating Engineering Society, the Engineers Club of Oklahoma City, and was a registered professional engineer in the State of Oklahoma. He had served on quite a number of committees of the AIEE Oklahoma City Section.

Sylvester Murray Viele (M '50), engineer, electrical engineering department, Pennsylvania Railroad Company, Philadelphia, Pa., died recently. Mr. Viele was born in Taylorsville, N. C., in 1886. He graduated from North Carolina State College in 1905 with a degree in electrical engineering. Following a year with the General Electric Company, he joined the engineering department of the Pennsylvania Railroad in 1906, retiring in 1952. Mr. Viele was active in the formulation of the high voltage safety codes for the States of Pennsylvania, Ohio, Indiana, and Michigan and was a member of the Executive Committee for the National Electrical Safety Code. He was chairman of the High Tension Cable Committee of the Association of American Railroads from 1931 to 1941. As supervisory engineer, he was responsible for the design of the electrical distribution system which formed the basis of all electrification on the Pennsylvania Railroad. His designs for lightning protection of transmission lines and substations are used throughout the world. Between 1933-38, he was active in the design and installation of the first successful radio communication system for use on moving trains. During 1944-45, he served on the National Radio Technical Planning Board. Mr. Viele was a member of the National Association of Corrosion Engineers, The Franklin Institute, and the Foundation for the Study of Cycles.

MEMBERSHIP

Recommended for Transfer

The Board of Examiners at its meeting of September 19, 1957, recommended the following applications for transfer. Any objection to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Member

Allison, L. R., section engineer, Westinghouse Air Brake Co., Union Switch & Signal Div., Swissvale, Pittsburgh, Pa.

Anderson, E. K., Jr. superintendent Substation Operation Dept., Consolidated Edison Co., New York, N.Y.

Arey, F. G., electrical engineer Chas. T. Main, Inc, Boston, Mass.

Atherton, E. W., manager equipment sales, I-T-E Circuit Breaker Co., Philadelphia, Pa.

Atkins, R. A., advance engineer, General Electric Co., W. Lynn, Mass.

Bejach, B. manager, product planning, General Electric Co., Small A-C Motor & Generator Dept., Schenectady, N. Y.

Bliklen, P. F., senior engineer, Arizona Public Service Co., Phoenix, Ariz.

Bliss T. J. electrical engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.

Brinson, A. P., senior engineer, Southern Services, Inc., Birmingham Ala.

Broeker, H. L., design & production engineer, General Electric Co., Schenectady, N. Y.

Brutt, F. J., electrical engineer, Westinghouse Electric Corp. Sharon, Pa.

Burdeshaw, T. A., engineering manager, Southern States Equipment Corp., Hampton, Ga.

Burgett, C. A., transmission design engineer, Public Service Co. of Oklahoma, Tulsa, Okla.

Campbell, D. S., chief Div. of Power, Dept. of the Interior, Washington, D.C.

Carlson, C. V., program engineer, Ohio Bell Telephone Co., Cleveland, Ohio.

Cole, R. L., engineering & service engineer, Westinghouse Electric Corp., San Diego, Calif.

Coleman, R. S., design engineer, Chas. T. Main, Inc., Boston, Mass.

Curry A. M. electrical engineer, Aluminum Co. of America, Pittsburgh, Pa.

Davis, R. J., sales engineer, Sun Valley Electric Mfg., Phoenix, Ariz.

Dreier, G. R., assistant electrical engineer, Pioneer Service & Engineering Co., Chicago, Ill.
Duncan, H. W., electrical engineer, Dept. of Water & Power, Los Angeles, Calif.
Durnford, R. F., associate professor, Montana State College, Bozeman, Mont.
Eick, R. W., electrical engineer, Dept. of Water & Power, Los Angeles, Calif.
Erdos, K. F., electrical designer, Catalytic Construction Co., Philadelphia, Pa.
Featham, A. E., senior research engineer, The Detroit Edison Co., Detroit, Mich.
Findley, J. D., Jr., senior engineer Westinghouse Electric Corp., East Pittsburgh, Pa.
Fricke, R. F., supervisory engineer, Westinghouse Electric Corp., Industrial Motor Engineering Lima, Ohio
Fuller, R. A., application engineer, General Electric Co., Ft. Wayne, Ind.
Gabbard, J. L., Jr., senior engineer, Union Carbide Nuclear Co., Oak Ridge, Tenn.
Geehr, Homer P., engineer of equipment, Bell Telephone Co. of Pa. (Eastern), Philadelphia, Pa.
Gentile, R. G., associate professor of electrical engineering, Clarkson College, Potsdam, N.Y.
Gill, W. D., superintendent of substations, British Columbia Electric Co., Ltd., Vancouver, B.C., Canada
Glassburn, W. E., engineering manager, Westinghouse Electric Corp., Newark, N.J.
Hall, G. J., assistant superintendent of power, Idaho Power Co., Boise, Idaho
Hamilton, R. L., product engineer, General Electric Co., Ft. Wayne, Ind.
Hanrahan, D. J., Electrical engineer, U. S. Naval Research Lab., Washington, D.C.
Hiatt, M. E., senior engineer, Indiana & Michigan Electric Co., Ft. Wayne, Ind.
Houser, R. W., electrical engineer, Aluminum Co. of America, Pittsburgh, Pa.
Howie, T. F., electrical engineer, Jack Moorman, electrical contractor, Shreveport, La.
Incuiet, I. J., manager engineering, Canadian General Electric Co. Meter & Instrument Section, Quebec, Que., Canada
Kallos, J., engineer, Philadelphia Electric Co., Philadelphia, Pa.
Kapfer W. A., electrical superintendent, Kaiser Aluminum & Chemical Corp., Mead Works, Spokane, Wash.
Kennedy, G. F., project engineer, IBM Corp., Poughkeepsie, N.Y.
Kerr, H. G., electrical engineer, Austin Engineering Inc., Midland, Mich.
Kogen, J. H., chief development engineer, Askania Regulator Co., Chicago, Ill.
Kotnik, R. L., project engineer, Fawick Corp., Fawick Airflex Div., Cleveland, Ohio
Krughoff, I. F., electrical development engineer, Union Electric Co., St. Louis, Mo.
Latimer, J., electrical engineer, Tennessee Valley Authority, Chattanooga, Tenn.
Lawson, H. H., product design engineer, General Electric Co., Philadelphia, Pa.
Lehman, A. J., superintendent of electrical engineering, Freeport Sulphur Co., Port Sulphur, La.
Lidster, J. R., outside plant engineer, B. C. Telephone Co., Vancouver, B.C., Canada
Lindseth, E. V., assistant director, Bureau of Reclamation, Denver Federal Center, Denver, Colo.
Lipkin, L., project engineer, Chrysler Corp., Missile Operations, Detroit, Mich.
Lowe, M. H., application engineer, General Electric Co., Erie, Pa.
MacLeod, D. D., senior engineer, Michigan Bell Telephone Co., Detroit, Mich.
Mann, J. R., manager of the transformer dept., Allis-Chalmers Mfg. Co., West Allis, Wis.
McCarron, J. F., Jr., president & treasurer, McCarron & Sullivan Associates, Boston, Mass.
McConnell, T. E., Jr., electrical engineer, Ebasco Services, Inc., New Orleans, La.
McKale, T. P., staff assistant, Commonwealth Edison Co., Chicago, Ill.
McMurtrie, D. L., Sr. electrical engineer & group leader, Raytheon Mfg. Co., Wayland, Mass.
Meisenheimer, L. F., operating engineer, system operating dept., Duke Power Co., Charlotte, N.C.
Meyer, M. M. M., general superintendent, Plains Electric Generation & Transmission Co-op. Inc., Albuquerque, N. Mex.
Miller, J. F., Jr., region manager, Motorola Communications & Electronics, Inc., Pittsburgh, Pa.
Munger, L. P., Jr., engineer, Alabama Power Co., Birmingham, Ala.
Peterfreund, L., senior electrical engineer, Glenn L. Martin Co., Middle River, Md.
Petrasuk, P., student, University of British Columbia, Vancouver, B.C., Canada
Pirofalo, C. J., squad leader, Pioneer Service & Engineering Co., Chicago, Ill.
Popa, J., design engineer, General Electric Co., Ft. Wayne, Ind.
Quisenberry, D. T., sales engineer, Westinghouse Electric Corp., Phoenix, Ariz.
Rabins, L., engineer, General Electric Co., Pittsfield, Mass.
Reuther, J. F., engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Rich, M., electrical engineer, Chas. T. Main, Inc., Boston, Mass.
Richards, H. H. C., Jr., design engineer, Westinghouse Electric Corp., Lima, Ohio
Ringold, D. R., electrical design engineer associate, Dept. of Water & Power, City of Los Angeles, Calif.
Roberts, R. W., engineering section manager, Westinghouse Electric Corp., Pittsburgh, Pa.
Robertson, E. P., engineer, The Detroit Edison Co., Detroit Edison Co., Detroit, Mich.
Rogers, A. G., senior engineer, Consumers Power Co., Flint, Mich.
Rowe, R. F., manager-aircraft & electronic transformer engineering, General Electric Co., Ft. Wayne, Ind.
Royer, G. H., staff engineer, International Business Machines, Poughkeepsie, N.Y.
Saba, E. T., sales engineer, The Euclid Electric & Mfg. Co., Allentown, Pa.
Sareault, M. A., superintendent, substation maintenance, Narragansett Electric Co., Providence, R.I.
Schlie, R. W., distribution system engineer, Rural Electrification Administration, U.S. D.A., Washington, D.C.
Schmitz, C. W., Jr., engineer B, Potomac Electric Power Co., Washington, D.C.
Schoffen, H. M., power operations engineer, PUD #1 of Chelan County, Wenatchee, Wash.
Schwalm, E. E., commercial & industrial manager, Omaha Public Power District, Omaha, Nebr.
Shepard, E. O., development engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Shoun, P. H., electrical engineer, Office of the Director of Power Operations, TVA, Chattanooga, Tenn.
Simons, A. A., manager of operations, Westinghouse Electric Corp., Idaho Falls, Idaho
Smith, E. P., equipment engineer, The Pacific Telephone & Telegraph Co., San Francisco, Calif.
Somers, R. B., deputy director, engineering, Atomic Energy Commission, Oak Ridge, Tenn.
Spademan, C. F., electronic engineer-research, Toledo Scale Co., Toledo, Ohio
Spiecer, M. S., engineer, The Chesapeake & Potomac Telephone Co. of Va., Richmond, Va.
Stewart, R.C.A., manager-utility sales, Canadian General Electric Co., Vancouver, B.C., Canada
Stolmack, H. W., principal engineer, Kaiser Engineers, Oakland, Calif.
Szabo, E. J., chief engineer, Leece-Neville Co., Cleveland, Ohio
Terry, W. W., engineer, Consolidated Edison Co. of N.Y., Inc., New York, N.Y.
Thorgerson, T. E., electrical engineer, Chas. T. Main, Inc., Boston, Mass.
Van Name, J. M., associate senior engineer in charge, Transmission Lines T & D Dept., Philadelphia Electric Co., Plymouth Meeting, Pa.
Weinerth, W., Philadelphia Electric Co., Philadelphia, Pa.
Whitcher, F. E., supervisor, Quality Control Equipment Design, General Electric Co., Erie, Pa.
Whitmire, C. N., substation supervisor, Florida Power & Light Co., Miami, Fla.
Whittlesey, J. I., generator advance engineer, General Electric Co., Schenectady, N.Y.
Williams, S. B., specialist-engineering procedures & programming, General Electric Co., Pittsfield, Mass.
Wilson, J. R., senior application engineer, General Electric Co., Dallas, Texas
Wilts, C. H., professor of electrical engineering, California Institute of Technology, Pasadena, Calif.
Wooldridge, D. P., engineer, Dallas Power & Light Co., Dallas, Texas
Wortman, H. B., section engineering manager & engineering design manager, Westinghouse Electric Corp., East Pittsburgh, Pa.

108 to grade of Member.

Applications for Election

Applications for admission or re-election to Institute membership in the grade of Member have been received from the following candidates, and any member objecting to election should so notify the Secretary before November 25, 1957, or January 25, 1958, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Bernhardt, E., president, Brown Boveri Canada Ltd., Montreal, Que., Canada
Brodie, G. H., director of engineering, Kellogg Switchboard & Supply, Chicago, Ill.
Brooks, G. G., supervisory engineer, Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Burke, B. S., Great Lakes regional manager, Federal Pacific Electric Co., Cleveland, Ohio
Burley, C. E., research supervisor, Reynolds Metals Co., Metallurgical Research Labs., Richmond, Va.
Case, P. W., development engineer, IBM, Poughkeepsie, N.Y.
Clark, B. C., staff electrical engineer, Refinery Engineering Co., Tulsa, Okla.
Epstein, S., assistant professor, electrical engineering, The Cooper Union, New York, N.Y.
Fork, F. W., manager of electrical marketing, H. H. Robertson Co., Pittsburgh, Pa.
Graves, W. P., assistant chief electrical engineer, U.S. Steel Corp., T. C. & I. Div., Fairfield, Ala.
Hanson, K. L., application engineer, electric Machinery Mfg. Co., Minneapolis, Minn.
Hill, F. J., district engineer, Mountain States Telephone & Telegraph Co., Butte, Mont.
Hoffner, C. C., technical adviser, Arnold Corp., Washington, D.C.
Lafferty, J. M., manager-Physical Studies Section, General Electric Co., Research Laboratory, Schenectady, N.Y.
Laurion, R. M., communications engineer, Copperweld Steel International Co., New York, N.Y.
Margolis, I., design supervisor, The Lummus Co., New York, N.Y.
Montgomery, G. C., electrical engineer, Tennessee Eastman Co., Kingsport, Tenn.
Nelson, C. V., research associate in biophysics, Maine Medical Center, Portland, Maine
Pierce, R. L., light & power superintendent, Milton-Freewater Utilities, Milton-Freewater, Oreg.
Reynolds, D. K., professor & head, electrical engineering dept., Seattle University, Seattle, Wash.
Richardson, C. D., insulation engineer, General Electric Co., Schenectady, N.Y.
Ridd, J. M., senior engineer, Pacific Tel. & Tel. Co., Los Angeles, Calif.
Roehrick, R. E., senior electrical engineer, Combustion Engineering, Inc., E. Chicago, Ind.
Rybczynski, W. K., cable engineer, Pirelli-Cables, Conduits Ltd., St. Johns, Quebec, Que., Canada
Skelton, G. H., acting electrical engineer, Bermuda Electric Light Co., Bermuda
Thompson, N. A., owner, Thompson Electric Co., Texarkana, Texas
Van Lieshout, L.J.A., manager, research & development, A. W. Haydon Div. of Consolidated Electronics, Waterbury, Conn.
Warren, G. B., vice-president, consulting engineer, Turbine Div., General Electric Co., Schenectady, N.Y.
Watkinson, H., member of laboratory staff, Bell Telephone Labs., North Andover, Mass.
Werner, E. H., electrical engineer, The Virginian Railway Co., Princeton, W. Va.
Wildi, T., professor, Laval University, Quebec City, Que., Canada

31 to grade of Member.

ELECTRICAL ENGINEERING EDUCATION

AIEE in Laval University

THE STUDENT BRANCH of the AIEE was formed at Laval University, Quebec, Que., Canada, on June 26, 1952. Its first counselor was Lionel Boulet, director of the department of electrical engineering. The present counselor is Dr. Maurice Boisvert, who was appointed in March 1955.

On March 1, 1956, the group was recognized as a joint AIEE-Institute of Radio Engineers (IRE) Branch by the two associations.

The Laval Student Branch is bilingual both in its membership and in its activities. At the present time, the majority of the students are French-Canadians, but all activities such as films and seminars are carried on in English.

The science faculty of the University, which includes electrical engineering, is housed in the Mining Building (*right*) which was built in 1941.

New Quarters Aquired by Brooklyn Polytechnic Institute

FOR THE FIRST TIME in its 103-year history, the Polytechnic Institute of Brooklyn (N.Y.) is located in new quarters this Fall.

As classes began on September 23, more than three fourths of the Institute's 5,900 graduate and undergraduate students moved five blocks north to a new home instead of returning to the century-old red brick buildings located on Livingston St.

The move represents the first major step in relocating one of the nation's largest schools of science and engineering which has "grown into" 15 scattered locations in the Borough Hall area of Brooklyn.

In 1953, Polytechnic purchased the block square industrial plant of the American Safety Razor Company for $2 million. Bounded by Jay, Johnson, and Lawrence Sts. and Myrtle Ave. and facing Brooklyn's new $125 million Civic Center, the site was deemed ideal for a school of science and engineering.

Conversion of the huge plant was begun in the fall of 1956. To date, remodeling has progressed to the point where the departments of physics; chemistry; mathematics; aeronautical, civil, mechanical, and metalurgical engineering; English; psychology; history; economics; modern languages; R.O.T.C.; and the alumni office are operating in the new building.

A modern cafeteria is in operation from 8 a.m. to 9 p.m.

Administrative offices and the departments of chemical and electrical engineering still are in Polytechnic's main building at 99 Livingston St. until the building operations are completed.

Throughout the summer, a stream of trucks carried tons of laboratory and classroom equipment from the original site to the new buildings. In many cases, department heads, full professors, and research personnel insisted on moving the delicate laboratory equipment by hand, carrying it gingerly through five blocks of Brooklyn traffic.

Conversion of the block square property gives the Polytechnic 320,000 square feet provided by two 8-story industrial type buildings and a 5-story administration building. It includes 65 classrooms in four sizes with seating capacities for 15, 30, 60, and 100 students respectively; 83 laboratories for research and teaching in chemistry, physics, and aeronautical, civil, chemical, electrical, mechanical, and metallurgical engineering; a library to house the Institute's scientific and technical collection; a modern cafeteria; club rooms and lounges; faculty and alumni lounge; and a 400-seat auditorium and lecture hall.

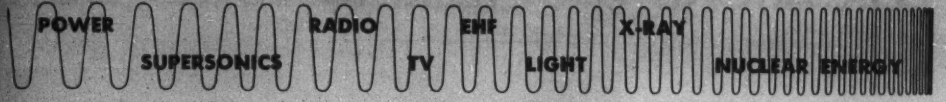
Polytechnic will retain the 3-century-old buildings located at 81, 85, and 99 Livingston St. until the new buildings are ready to receive the administrative offices and the departments of chemical and electrical engineering.

Already vacated property on the south side of Livingston St. and on Schermerhorn St. will be sold as will the three buildings (81, 85, 99 Livingston) which are behind the court buildings. Rented quarters also have been vacated.

However, Polytechnic's Microwave Research Institute, which annually expends more than $1 million in electronic research, will remain in its present building at 55 Johnson St.

Structural engineers for the conversion are Seelye, Stevenson, Value and Knecht. Mechanical engineers are the Cosentini Associates. A. L. Craft, 133 E. 39th St., was the architect. W. J. Barney Corporation, 101 Park Ave., co-ordinated and supervised the conversion. Associate Dean C. E. Schaffner was project representative for Polytechnic.

Electrical Engineering Education



Vanguard Essay Contest Winners Announced

Three recent college graduates from different corners of the United States took a $17,000 plane ride to Baltimore, Md., to be awarded the top three prizes in The Martin Company's Vanguard Satellite Essay Contest on September 26, 1957. In addition to these three top awards, The Martin Company, prime contractor for designing and building the International Geophysical Year (IGY) earth satellite launching vehicle, announced seven $500 honorable mention Vanguard Essay winners.

The Martin Company also awarded matching amounts to the college of each of the 10 top winners. This contest, open only to college senior or graduate engineering students throughout the country, had application requests from students in over 200 universities.

First prize, consisting of a $5,000 cash award went to Theodore Lang of Pasadena, Calif., an engineering student from California Institute of Technology, who wrote his paper on the subject: "An Equilibrium Trajectory for a Satellite Powered by Solar Pressure." A similar $5,000 matching award was made by the company to California Tech. In his winning essay Mr. Lang theorizes that, "A specially designed satellite could be maintained in a circular orbit about the earth by utilizing solar radiation pressure as a driving medium," to prolong the life of the satellite.

Second place went to R. L. Howell, of Cambridge, Mass., a recent graduate of Massachusetts Institute of Technology, whose subject was: "A Satellite Beacon Station." Lieutenant Howell at present is stationed at Patrick Air Force Base in Cocoa, Fla., where coincidentally the earth satellite will be launched. A $2,500 prize was awarded to Lieutenant Howell.

The third prize of $1,000 went to Eugene Mechtly of Northampton, Pa., who studied engineering at Pennsylvania State University. Mr. Mechtly wrote on the subject of "A Technique for Increasing a Satellite's Energy Weight Ratio."

The seven runner-up winners, each of whom received a $500 Honorable Mention cash award are listed as follows: D. J. Beaubien, University of Massachusetts; Eugene Covert, Massachusetts Institute of Technology; R. J. Gebelein, University of Rochester; E. A. Ullrich, Jr., University of New Mexico; R. J. Stoffel, University of Missouri; R. G. Kittlitz, Jr., University of Mississippi; and C. A. Barth, University of California.

The three judges of the Vanguard Essay Contest, all prominent individuals connected with the Vanguard earth satellite project are G. S. Trimble, Jr., vice-president--engineering of The Martin Company; Dr. Joseph Kaplan, professor of physics at the University of California, and chairman of the U.S. National Committee for the IGY; and Dr. John Hagen, Naval Research Laboratory, director of Project Vanguard. Total value of prizes awarded was $24,000.

"Principles and Practices of College Recruiting" Published

Broad proposals to protect college students from high-pressure job recruiting tactics were published recently by the Chamber of Commerce (CC) of the United States and the College Placement Council, Inc. (CPCI).

Entitled "Principles and Practices of College Recruiting," the publication offers a single set of recruiting standards for voluntary acceptance by all colleges and employers, including Government agencies. It also seeks to end confusion brought about by the many current statements on college recruiting standards.

The CC pointed out that in addition to safeguarding students, the proposals would protect the many employers who have refused to high-pressure youngsters they seek to hire after graduation.

Questionable recruiting tactics, the CC said, result from the increase in organizations actively seeking future employees on college campuses, from less than 1,500 before World War II to more than 6,000 today.

Among practices disapproved by the new recruiting guide are the bidding up of salary offers by competing employers, elaborate entertainment of prospective student employees, special payments or other gifts, any undue influence on student job choices by faculty members, and expense account padding by students visiting company plants.

Principal objective of the proposals is to promote "a wise and responsible" choice of career by the student himself and "to strengthen in him a high standard of integrity and a concept of similar standards in the employing organizations of the country."

The publication lists specific responsibilities for students, colleges, and employers in order that selection of a career can be made "in an objective atmosphere with complete understanding of all the facts."

Recommendations are based on studies by business groups, Federal agencies, college placement officials, and officers of private and state universities brought together by the CC and the CPCI. Incorporated are earlier statements on recruiting by the Midwest College Placement Association, the American Society for Engineering Education (*Electrical Engineering*, October 1957, pages 924-26), the Eastern College Personnel Officers, and the Manufacturing Chemists Association. Highlights of recruiting recommendations follow:

(1) Colleges should provide competent counselling services, available to individual students, as a part of their general responsibility for development of the student.

(2) Information provided to students about an employer should be strictly factual. The student should be given a clear understanding of the requirements of his employment and of the fact that advancement will depend upon his own ability and effort.

(3) No special bonuses or similar financial incentives should be given to influence a student's consideration of an employer's offer.

(4) Acceptance of an employment offer by the student should be made in good faith and with the sincere intention of honoring his employment commitment.

Copies of "Principles and Practices of College Recruiting" are available from the Education Department, Chamber of Commerce of the United States, 1615 H St., N. W., Washington 6, D. C., at 25c per single copy, or 10 copies for $1.00. Bulk orders, $6.00 per hundred.

First Award of Alex Dow Fellowship

The first award of the newly created Alex Dow Fellowship in Engineering has been made to W. A. Porter of South Haven, Mich. The announcement was made by W. L. Cisler, president of the Detroit Edison Company.

Mr. Porter, who is a 1957 graduate of Michigan College of Mining and Technology in Houghton, will receive a $1,500 grant, plus tuition, for one year of post-graduate study at the University of Michigan where he plans to earn a master's degree in electrical engineering.

The fellowship, which also provides for an $800 grant to the department in which the student is enrolled, was established by Detroit Edison in memory of Alex Dow, the electric power industry pioneer who headed the company from 1912 through 1940. According to present plans, the award will be rotated annually among several colleges and universities, each of which will be asked to select a recipient.

To be eligible for the Alex Dow Fellowship, a student must be male, an American citizen, and not over 25 years of age at the time of registration for advanced study. He must have an undergraduate degree with plans for continued study in electrical engineering, majoring in power systems studies; mechanical engineering,

majoring in thermodynamics and power studies; or nuclear engineering, majoring in reactor technology for power generation. In addition, the recipient must have shown by undergraduate work and summer employment both aptitude and interest in some engineering aspects of the electric power industry.

Porter, who began his advanced studies at the University of Michigan this Fall, has been active in student branches of the AIEE and Institute of Radio Engineers. His memberships in honor societies include Phi Eta Sigma, Tau Beta Pi, Phi Kappa Phi, and Etta Kappa Nu.

UW College of Engineering Reports on Research Projects

The amount of research carried on in the University of Wisconsin (UW) College of Engineering increased more than 14% to reach a new high of 235 projects during 1956-57, it was revealed in the UW Engineering Experiment Station report for the past year made public recently.

The annual report was compiled by UW engineering Dean K. F. Wendt, director of the station, and Prof. W. R. Marshall, Jr., associate dean and director.

"Those who have followed the annual reports will note that most of the hopes expressed in previous years as to new programs of research have been realized to a remarkable degree," Dean Wendt stated.

"Specifically, the program to identify, encourage, and conserve our superior high school students is gaining momentum and even at this early stage gives promise of excellent results. The solar energy studies have, in part, been carried to the field testing stage, and new programs in solar engines and absorption cooling have been started. Some of the effects of low temperatures on combustion have been evaluated, and an experimental burner has been developed.

"The Electrical Standards and Instrumentation Laboratory and the Network Calculator Laboratory have rendered valuable service to industries of the state and at the same time have inaugurated important research studies growing out of the service problems," he said.

"During the year, proposed graduate program in Nuclear Engineering at the master's degree level was developed. It is hoped that this will be in operation in the Fall of this year. Special equipment is under study and will be procured shortly. Soon thereafter, we can expect to see several new research programs in the nuclear field under way."

The report reveals that while the total number of engineering research projects increased more than 14% during 1956-57 over the previous year, and the number of persones engaged in research increased almost 14%, funds budgeted for the research decreased 10% because of smaller expenditures for costly equipment and for graduate student research support.

"Our engineering faculty and staff members and our graduate students are getting a great deal of research work done on a minimum budget," Dean Wendt said.

The number of engineering research projects during 1956-57 increased from 206 to 235; the number of faculty–staff–graduate students engaged in research increased from 204 to 232; but total funds allotted to research dropped from $487,970 to $442,801.

Of the total of 232 engineering faculty–staff–graduate students engaged in research, only 9 devoted full time to the work, whereas 223 were engaged in part-time research, devoting the rest of their time to teaching, administrative work, or study.

The total of $442,801 in research funds came from the following sources: industrial grants and fellowships, $105,980; state funds, $103,000; foundations, $93,086; Wisconsin Alumni Research Foundation, $88,735; and Federal Government, $52,000.

UW engineering faculty members published a total of 26 papers on their research during the year, bringing the total publications of staff members to 305; 3 additional Wisconsin Engineering Experiment Station research reports were published; 95 students were granted master's degrees and 24 doctor's degrees in engineering; and 22 students were granted graduate fellowships ranging in value from $1,500 to $2,400.

Auckland University Engineers' Association Formed

There has recently been formed the "Auckland University Engineers' Association," membership of which is open to members of the staff (past and present), graduates, and past students of the School of Engineering, Auckland University College.

The Association aims to promote closer relationships between members and between them and the School. It also hopes to compile and publish a Newsletter at regular intervals.

Persons who are interested in further details about the Association are invited to write to J. H. Percy, Secretary, Auckland University Engineers' Association, Auckland University College, Auckland, New Zealand.

An Electrical Engineer in Industry

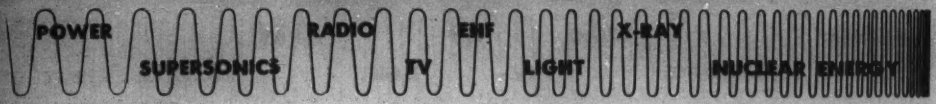
T. W. MILLER (AM '46), section head, Perkin-Elmer Corporation, Norwalk, Conn.

"The day finally comes when you receive your coveted 'sheepskin.' You now become in your own eyes and in those of your potential employer, a full fledged electrical engineer. But wait, how do you plan to establish and maintain eminence in your chosen field? By getting a position? By working diligently at it? Of course, but don't stop there. Affiliate yourself with a technical society, one with the dignity and respect of the experienced engineer. Such an affiliation enables you to keep abreast of the technical times. The AIEE is such an organization. It is a service to you. Journal and Transaction publications are the daily newspapers of your field. Its planned local and national conferences provide a common meeting ground for the dissemination and exchange of ideas between you and your equals. Active participation in its activities widens your circle of acquaintances and furnishes valuable contacts. In a word, it's your club and fraternity for the many years of your professional life."

Mr. Miller received the bachelor's degree in electrical engineering from New York University in 1942 and the master's degree in electrical engineering in 1947 from the same university. His background includes designing broadcast receivers, acting as sales engineer for computer systems, and as project engineer on computers.

Mr. Miller has been associated with the AIEE since he became a student member of the Institute in 1941.

Electrical Engineering Education



Changes Predicted in the Education of Engineers

Far-reaching changes in the education of engineers have been predicted by Dr. J. T. Rettaliata, president of Illinois Institute of Technology.

The prospective engineering student can look forward to more emphasis on the sciences and humanities, and less attention to applications during his undergraduate days.

"Specialization will move to the graduate area," he said, and "it will not be too long before a graduate degree is the minimum requirement in engineering, as is the case in the sciences."

The remarks were made at the opening session of a four-week graduate engineering program sponsored by the Western Electric Co. at Illinois Tech.

During the program, 40 engineers from Western Electric plants stretching from Massachusetts to Nebraska were briefed on the latest developments in electronic computers, plant layout, materials handling, and industrial controls.

The courses are part of a multimillion dollar graduate engineering program financed by Western Electric. It will involve some 2,000 engineers a year across the nation when in full operation.

"The undergraduate engineering program, as now organized, does not provide the desired depth and breadth of scientific foundation and the background for creative thinking that is so essential in today's fast-moving world," Dr. Rettaliata said.

He pointed out that steps are being taken to prepare engineers who are well grounded in fundamentals and possess the ability for creative thinking.

"The effect of these modifications will be to approach unification of the various engineering disciplines at the undergraduate level," he explained.

"The majority of the program will be the same for all engineers, with those courses defining the major discipline not exceeding several semesters out of the four years."

Dr. Rettaliata said there is no easy solution to the problem, just as there is no ready answer to the engineering manpower shortage.

He urged the engineers and their professional societies to assist in attracting more students to engineering and science.

"There is an urgent need for a greater effort to reach into the high schools and to bring engineering and science as a splendid career to the attention of American youth.

"You can help in discovering and encouraging students with natural abilities for engineering and science to pursue such studies at a higher level," the Illinois Tech president said.

Dr. Rettaliata pointed out that only about half of the top 5% of high school graduates go to college.

"This is indeed a tremendous loss of America's brightest youth, and it certainly deserves the considered thought of each of you, and the societies to which you belong," he said.

Research Reactor To Be Built at Georgia Tech

Governor Marvin Griffin of Georgia pledged $2.5 million on August 20 to be used to construct a high-flux research reactor for the Georgia Institute of Technology (Georgia Tech).

The pledge was made at a luncheon meeting of the Georgia Nuclear Advisory Commission immediately after Dr. W. H. Zinn, internationally known nuclear physicist, outlined the conceptual design for the Georgia Tech reactor. The design was carried out by the General Nuclear Engineering Corporation of which Dr. Zinn is president.

The Governor's pledge gave the final green light to a three-phase expansion program in the nuclear field at Georgia Tech.

The first phase, the nuclear graduate program, began in the fall quarter of the 1956-57 scholastic year. This graduate level program leads to a master's degree in either nuclear science or nuclear engineering, depending on the student's major field. A candidate for a degree in this program begins graduate work in the school of his bachelor of science degree where he takes his master's degree work. A necessary portion of his work will be in the nuclear field, designed to give a thorough grounding in nuclear science and technology.

In 1956, Governor Griffin appropriated $500,000 to the Regents for phase two of the planned program, the building and equipping of a radioisotopes laboratory building on the Georgia Tech campus. The building, now valued at $500,000 as a result of additional grants from the National Institutes of Health and Georgia's Board of Regents, is to be constructed this Fall. It will provide laboratory space and facilities for courses taught in connection with the nuclear graduate program as well as for research.

Beginning with the formation of a Nuclear Science Committee in January 1955, Georgia Tech's program has moved steadily forward through the addition of new courses to the curriculum and of nuclear scientists to the faculty and staff. A grant has been made to Georgia Tech by the Atomic Energy Commission (AEC) for equipment and special supplies to be used in nuclear science and technology courses. Georgia Tech also has taken advantage of the AEC's educational support program to acquire 5,500 pounds of uranium and a neutron source for use in a subcritical assembly constructed at the school and now in operation. It is the objective of this extensive new program at Georgia Tech to be of broad value to education, industry, and agriculture in Georgia and in the South.

Georgia Tech's subcritical assembly, temporarily located in the campus power plant building, will be moved to a large physics instruction laboratory in the Radioisotopes Building. The completely air-conditioned building will also contain a radiochemistry instruction laboratory, bioengineering laboratories, and other research laboratories, as well as a storage and handling laboratory for materials containing up to approximately one curie of radioactivity. It will also have a counting room, an electronics shop, and office space.

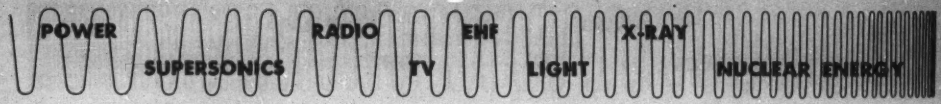
The new reactor will be a heavy-water moderated heterogeneous enriched fuel type, similar to the *CP-5* now in operation at Argonne National Laboratory. The reactor will be used in a broad and intensive program for research in physical and engineering sciences. It also will contribute to research in biological, agricultural, and medical sciences in the region, as well as make more comprehensive and effective the Georgia Tech graduate program in nuclear science and engineering.

Dr. W. B. Harrison, III, research professor of mechanical engineering at the Georgia Institute of Technology, is the director of the Georgia Tech research reactor project.

ORINS Courses in Radioisotope Techniques

The Special Training Division of the Oak Ridge Institute of Nuclear Studies (ORINS) has announced the following 1958 schedule of four-week courses in the basic techniques of using radio isotopes: January 6-31, February 3-28, May 19–June 13, June 16–July 11, August 11–September 5, and September 8–October 3.

The ORINS Special Training Division conducts these courses in Oak Ridge, Tenn., for the U. S. Atomic Energy Commission (AEC), to assist mature scientific and technical personnel in obtaining in a short time sufficient facility in the use of radioisotopes to handle them safely and efficiently. Attendance is limited to those individuals who are



using or who may be expected to use radioisotopes in the near future.

Radioisotope-techniques courses consist of laboratory work, lectures on laboratory experiments, general background lectures, and special-topic seminars, with most time devoted to the laboratory.

Minimum scholastic requirement for admission to the courses is a bachelor's degree, preferably in a scientific field. No particular courses are, however, required as prerequisites. Advanced study and work experience in a field in which radioisotopes can be used are desirable, and preference is given to applicants with such background. Priority is given in the summer courses to university personnel.

Further information concerning these courses may be obtained by writing Dr. R. T. Overman, chairman, Special Training Division, ORINS, P. O. Box 117, Oak Ridge, Tenn.

Home-Study Course in Nuclear Energy Available

Announcement of a home-study course in the field of practical applications of nuclear energy has been made by Steiner Nuclear Services of Baltimore, Md.

The course of study consists of 12 lessons. No supplemental text books or references are required as all necessary material is included. Each student is assured of individual attention by separate examination of the work he submits. The course has been approved by the Maryland State Department of Education and the material prepared in consultation with the U. S. Atomic Energy Commission. A high school diploma is the scholastic requisite.

An interesting, informative folder is available from Steiner Nuclear Services, 7503 Seven Mile Lane, Balitmore 8, Md.

Engineering Scholarship Awarded by Kiekhaefer Corp.

A program of university scholarships in engineering has been established by the Kiekhaefer Corporation of Fond du Lac, Wis. The awards will be made periodically to young men who need financial assistance in their engineering education and who have shown mechanical aptitude and interest in outboard motors and two- and four-cycle engines through their activities in outboard racing, motor maintenance, and motor sales, or in their previous education.

In announcing the program, Carl Kiekhaefer, president, said that its purpose was to stimulate young men to become engineers in the outboard industry "as it enters what promises to be its greatest period of development."

He said the first scholarship has been awarded to Craig Dewald of Reading, Pa., for four years study starting this Fall in the department of engineering in a university of his choice.

GE Grants Go To College Physics Departments

The General Electric (GE) Educational and Charitable Fund has announced grants totaling $50,000 to 20 college physics departments.

Each of the selected liberal arts colleges will receive unrestricted grants of $2,500 under the Fund's new College Science Grants Program. How the money will be used to strengthen the physics departments is left to the discretion of the recipient college.

In the majority of cases, the amount of the grant is about the same as the normal annual budget for the physics department, salaries excluded.

K. G. Patrick, secretary of the Educational and Charitable Fund, said that representatives of the company's Research Laboratory had visited all of the selected colleges prior to awarding the grants.

It is anticipated that the money will be used to improve faculty compensation, purchase needed equipment, scientific periodicals and library assistance, for attendance at scientific meetings, and for special projects, depending upon the need of the individual college to increase the effectiveness of its physics department.

Although the current grants are for the 1957-58 academic year, Mr. Patrick said that it is hoped that the program may be continued beyond the present one-year authorization.

The Educational and Charitable Fund was established by GE to further its interests along these lines and various programs are sponsored by the Fund, including the Corporate Alumnus Fund which matches dollar for dollar the contributions of company employees to colleges.

This program was established two years ago as an incentive to company employees to make gifts to their alma maters. During the current year, the Fund has increased to $2,000 the top limit per employee per year. Any gifts made by employees under the program are matched dollar for dollar by the Fund up to $2,000 per year.

In addition, the Fund sponsors summer fellowships for 300 secondary school science and mathematics teachers and fellowships and scholarships for graduate and undergraduate students.

The following colleges received the $2,500 grants for their physics departments: Allegheny College, Meadville, Pa.; Bates College, Lewiston, Maine; Beloit College, Beloit, Wis.; Colorado College, Colorado Springs, Colo.; Concordia College, Moorhead, Minn.; DePauw University, Greencastle, Ind.; Eureka College, Eureka, Ill.; Kalamazoo College, Kalamazoo, Mich.; LeMoyne College, Syracuse, N.Y.; Linfield College, McMinnville, Oreg.; Middlebury College, Middlebury, Vt.; Mount Holyoke College, South Hadley, Mass.; Pomona College, Claremont, Calif.; Reed College, Portland, Oreg.; Roanoke College, Salem, Va.; Rollins College, Winter Park, Fla.; St. Olaf College, Northfield, Minn.; Union College, Schenectady, N.Y.; Whitman College, Walla Walla, Wash.; and College of Wooster, Wooster, Ohio.

EUSEC Booklet on Engineering Education

Engineers' Council for Professional Development (ECPD) has announced the availability of the publication entitled "EUSEC—Engineering Education and Training," which represents the United States contribution to the Conference of the Engineering Societies of Western Europe and the United States of America (EUSEC), September 16-20, 1957, Paris, France.

ECPD represents the five United States societies in EUSEC—AIEE, American Society of Civil Engineers, American Institute of Mining, Metallurgical and Petroleum Engineers, American Society of Mechanical Engineers, and American Institute of Chemical Engineers.

Included in the booklet are the following engineering education reports: Glossary, Organization of and Terms Used in Education in the United States of America with Special Reference to Engineering Education; General Education and Selection for Admission to Engineering Schools of University Level in the United States of America; Education at Engineering Schools of University Level, Submitted on Behalf of the United States of America; Practical Training Before, During, and After Engineering Studies in the United States of America; General Report on Criteria for Professional Recognition in the United States of America; Post First Degree Education of Engineers in the United States of America.

Responsible for the reports contained in the booklet is a committee composed of H. H. Armsby, chief for engineering

education, U. S. Department of Health, Education and Welfare, Office of Education; M. M. Boring, consultant on manpower, General Electric Company, Schenectady, N. Y.; H. L. Hazen, dean, The Graduate School, Massachusetts Institute of Technology; and Thorndike Saville, dean, College of Engineering, New York University.

A price of $5 per copy of the publication has been set. In quantities of 25 or more there will be a 20% discount. Order from ECPD, 29 W. 39th St., New York 18, N. Y.

TSMC Renews Electronics Fellowships

W. H. Cooley, president of Television Shares Management Corporation (TSMC), pioneer investment management organization in the electronics field, has announced the renewal of three fellowships established last year at three major universities to aid graduate students striving for advanced degrees to further their teaching careers in this field. Mr. Cooley said that TSMC had granted $6,000 for the 1958-59 academic year, divided equally among Massachusetts Institute of Technology, Stanford University, and University of Illinois.

Last year's grants, for a similar amount of money, went to six graduate students at the three recipient universities. The grant of $2,000 to Massachusetts Institute of Technology was divided among four graduate students who are E. P. Gyftopoulos of Athens, Greece; D. R. Whitehouse of Cambridge, Mass.; W. A. Youngblood of Mart, Texas; and T. G. Stockham, Jr., of Upper Montclair, N. J. C. W. Simmonds of Salt Lake City, Utah, received the full $2,000 grant from Stanford University and J. R. Young of Rockford, Ill., was awarded the $2,000 at the University of Illinois.

Mr. Cooley stated that the grants made by TSMC stem from a desire to encourage and support teachers to train the future engineers and scientists in the electronics field. "We have noted little inducement," he said, "for young men to enter the teaching profession in this vital area. As a result, a critical situation exists which, if it continues, could seriously affect educational standards in this field as well as vitiate the effort now being made by industry to recruit qualified engineers from our universities. We feel that it is of primary importance to the nation to encourage and develop teachers in the vital sciences. Without sufficient and competent teachers, industry cannot long expect to be able to fill its needs for qualified graduate engineers and scientists."

The decision to make the grants, Mr. Cooley added, resulted from discussions with members of the Advisory Board of Television-Electronics Fund, Inc., a mutual investment company, which Mr. Cooley's firm serves as investment manager and principal underwriter. Three of these are faculty members of the universities to which the grants were made. They are: Dr. W. L. Everitt (F '36), dean of the College of Engineering at the University of Illinois; Dr. F. E. Terman (F'45), provost and dean of the School of Engineering at Stanford University; and Dr. J. B. Wiesner, director of the Research Laboratory of Electronics at Massachusetts Institute of Technology.

Small Atomic Energy Reactor for School Labs

Operation of a miniaturized atomic energy reactor, designed by Atomics International, a division of North American Aviation, Inc., for school, medical, and industrial laboratories is under way at the company's plant in Canoga Park, Calif., it was announced recently.

Only eight feet high and eight feet in diameter, the "Laboratory Reactor" can be installed in any existing laboratory building without the addition of any special facilities.

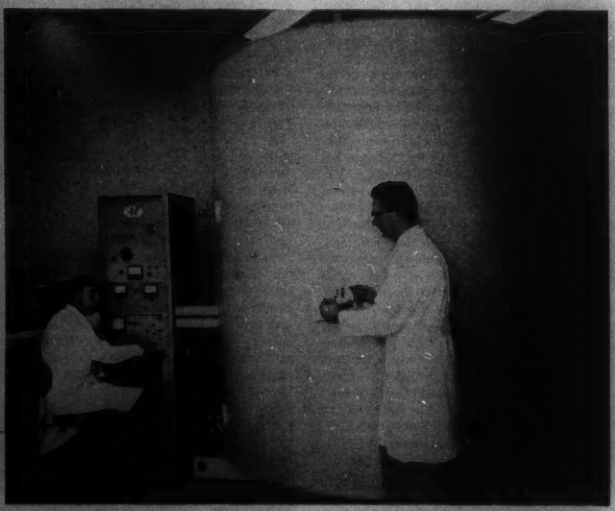
The low-priced Laboratory Reactor can be constructed, installed and ready to run at any location on a short delivery schedule.

The reactor permits a wide range of research and training in the nuclear field and provides nuclear radiation for important studies in the engineering, biological, and medical fields. It is designed to operate at a power level of five watts.

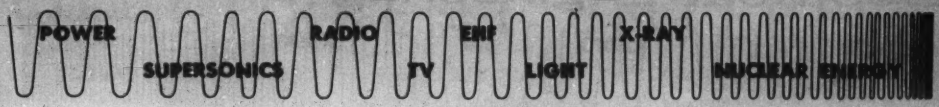
The "core" of the reactor, where atomic fission takes place, is a one-foot stainless steel sphere containing about four gallons of enriched uranyl sulfate in a water solution. This core, surrounded by a lead shield, six inches thick, is housed in an eight-foot tank filled with ordinary water. A number of exposure facilities and beam tubes are provided to permit several experiments to be carried on while the reactor is operating.

Only one person is required to operate the reactor, which is controlled from a single console panel.

"The Laboratory Reactor is a low-cost



OPERATION of this miniaturized atomic energy research reactor, only eight feet high and eight feet in diameter, is under way at Atomics International, a division of North American Aviation, Inc. Designed by the company to fit into any school, industrial, or medical laboratory, the "Laboratory Reactor" can be installed without adding special facilities. Physicist *(right)* inserts an experiment into the "core" or heart of the reactor, while an associate *(left)* prepares to operate the reactor from the single console panel.



reactor designed to meet the special needs of schools," according to a statement made by Dr. A. B. Martin, director of technical sales for Atomics International. "The numerous experiments and demonstrations which can be performed make it an invaluable aid for courses in nuclear engineering, neutron physics, radiochemistry, and radiobiology," Dr. Martin said.

NSF Reports on Faculty Scientific Research Activities

A survey of faculty engaged in scientific research activities in United States academic institutions, released by the National Science Foundation (NSF), indicates that in 1953-54, 70,000 scientists and engineers were employed by colleges and universities, about half of whom were performing research on a full- or part-time basis. In a large sense, this group represents a reservoir of the nation's basic science research potential inasmuch as the survey covered 1,120 institutions capable of performing research in the natural and social sciences. Other academic institutions in the country are primarily teachers' colleges or oriented toward education in the liberal arts.

The estimates derive from the NSF survey of scientific manpower at colleges and universities for the academic year 1953-54, and are based on data returned by 987 responding institutions. These institutions reported 62,000 faculty members in the natural and social sciences, and an estimate of 8,000 was made for nonresponse. Of the respondents, 180 were large institutions, i.e., primarily those having graduate schools in the scientific professions. These accounted for 46,500 of the total scientific faculty, and for 95% of the total research time reported.

The reported faculty members included both full- and part-time scientists and engineers engaged in any or all of the normal duties of a faculty member—teaching, research, and community service. Translating part time and full time into full-time equivalents, about 30% of the total time was devoted to research activities.

The NSF report presents number of faculty in these institutions and the percent engaged in research in six different types of organizations within the universities: arts and sciences, engineering, health, professional, agriculture, research organizations, and other professional schools. About 75% of the total faculty employed were in the arts and sciences, engineering, and medical schools.

Scientific fields being investigated by these faculty members are also shown in the report. Approximately one third of those performing research were in the physical sciences—such as engineering, chemistry, physics, and mathematics; one third in the life sciences—biological and clinical; and the other one third pursue investigations in the agricultural and social sciences.

The supporting research personnel reported by the large (180) institutions indicate a one-to-one ratio to the faculty. This computation is based on the full-time equivalents for both the faculty and supporting personnel.

The report, "Faculty Scientific Research Activities at Colleges and Universities, 1953-54," is Number 6 in the NSF series entitled *Reviews of Data on Research and Development*. Copies may be obtained by writing to the National Science Foundation, Washington 25, D. C.

Georgia Tech Students Win Lighting Design Contest

Two students at the Georgia School of Technology won first honors in the nation-wide Allied Arts contest conducted annually by the Illuminating Engineering Society (IES) as part of its national technical conference.

John Reece, an architectural student, and W. Y. McCachern, an electrical engineering student at Georgia Tech, led in the final balloting with a restaurant design. Their sketches and specifications, conceived co-operatively, were submitted by Professor Howard McKinley of the Electrical Engineering School.

The contest is conducted through several universities in various parts of the country to spread knowledge of the art and science of illumination as an integral part of building-design courses.

NYU Buys Million-Volt "Atom Smasher"

A million-volt particle accelerator, or "atom smasher" has been ordered by New York University (NYU) from the High Voltage Engineering Corporation in Burlington, Mass.

The supervoltage Van de Graaff machine will be used to accelerate positive ions and as a source of neutrons, and will be used for training nuclear engineers in the reactor field. The University's curricula embracing many phases of industrial applications of atomic energy has laid increasing stress upon reactor design and operation. Acquisition of the new Van de Graaff will enable the atomic energy department, under the direction of Dr. Lyle Borst, to operate the school's "pickle barrel" subcritical reactor with precise control.

To set up the "pickel barrel" program, High Voltage engineers and physicists worked with Dr. Borst last year. The "pickle barrel" actually consists of a 100-gallon barrel containing 2 tons of unenriched uranium metal. NYU researchers, using the Van de Graaff in conjunction with the "pickle barrel," can simulate problems in reactor behavior for a fraction of the cost of full-scale evaluation.

Scholarship Awarded by International Nickel Company

A liberal arts student is the recipient of the International Nickel Company scholarship at Illinois Institute of Technology (IIT), Chicago.

The scholarship will enable F. G. Stremler, Lynden, Wash., to acquire an engineering education in addition to his liberal studies.

Mr. Stremler, a student at Calvin College, Grand Rapids, Mich., will major in electrical engineering.

In addition to covering tuition, the award provides $300 each year for books and living expenses. The scholarship is renewable for the second year.

Established by the International Nickel Co., Inc., New York, N.Y., the scholarship is awarded to students who transfer to IIT from one of 29 liberal arts colleges participating in IIT's "3-2" combined education plan.

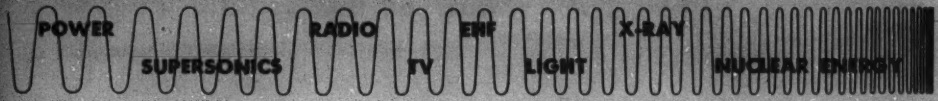
Under the "3-2" plan, a student spends three years in a liberal arts college and two years at IIT to receive both a liberal arts and an engineering degree at the end of five years.

Teen-Agers Receive Cash Scholarships in Hughes Program

A group of 12 outstanding high school students in the greater Los Angeles, Calif., area received cash scholarships totaling $4,800 August 29 from Hughes Aircraft Company, in ceremonies at the company's Culver City Laboratories concluding a 10-week research project carried out there by the teenagers. The presentation of a $400 check to each student for future college expenses climaxed a summer-study scholarship program initiated by Hughes with the co-operation of public school officials, to encourage talented students to choose careers in science and engineering.

The 10 boys and 2 girls, juniors and

Electrical Engineering Education



seniors talented in science and mathematics, were picked for the program last spring from a group recommended by educators in Beverly Hills, Centinela, Compton, Culver City, El Segundo, Inglewood, Redondo-Union, Santa Monica, Torrance, and the Los Angeles public school districts. Each received an additional $400 in salary from Hughes for the 10-week research project, according to J. M. Glass, company scientist and chairman of the summer-study program. Research by the students concerned civil defense planning in the Los Angeles area and was separate from regular company research projects.

"The summer-study scholarship program is the newest of several Hughes projects aimed at interesting more youngsters in scientific careers," Mr. Glass said. Existing company programs include the summer hiring of high school science and mathematics instructors as professional workers in the Hughes laboratories, and lectures by Hughes scientists in high school classrooms. In July, the company was cosponsor with the National Academy of Sciences of a national industry-education conference at Lake Arrowhead to determine ways of improving science instruction in the nation's schools.

The 10-week student research project was supervised by Dr. John Balloch of the operations research office of Johns Hopkins University.

During the summer program, students also toured the Hughes laboratories and heard a series of lectures on new scientific discoveries.

Teachers Return to School In NSF-Sponsored Institutes

When the fall school term opened this year, some 800 high school teachers of science and mathematics themselves returned to school for a concentrated year of study. Under the sponsorship of the National Science Foundation (NSF), 16 universities geographically distributed throughout the country are offering specially designed courses to bring selected high school teachers up to date in the various fields of science and in mathematics. The program, costing approximately $4.25 million, has been developed by the NSF in response to the express desire of the United States Congress that the NSF make a broad frontal attack in meeting the need for improved teaching of science and mathematics at the high school level.

Universities participating in the program are as follows: Chicago, Colorado, Harvard, Illinois, Michigan, North Carolina, Ohio State, Oklahoma State, Oregon State, Pennsylvania State, Stanford, Texas, Utah, Virginia, Washington University at St. Louis, and Wisconsin.

Within a very general framework prescribed by the NSF, each university has planned and developed the type of institute best suited to its own staff and facilities. In addition to the special year of intensive training, the courses in most instances also carry full academic credit.

High school teachers selected to participate in the institutes will receive stipends of $3,000, plus an allowance of $300 for each dependent, up to a maximum of four. Additional allowances include travel, up to a maximum of $80 for each of two trips from the teacher's home to the institute, and funds for tuition and books. Financial assistance of this type represents the only means by which the majority of high school teachers can take time off for their own improvement.

Most of the participating universities are offering courses for the teachers in biology, chemistry, mathematics, and physics, plus some supplementary work in education. Some of the schools are also including courses in the history of science. In addition to regular lectures and laboratories, many of the institutes include seminars and special series of lectures by distinguished scientists and mathematicians. Lectures will be devoted to such current topics as the International Geophysical Year, progress in the conquest of disease, utilization of nuclear energy, and others. In one university, opportunity will be afforded the student teachers to observe modern teaching methods in one of the regular courses of the university.

Many teachers will be introduced for the first time to modern, large-scale research facilities including the cyclotron, Van de Graaff generator, radiotelescope, mass spectograph, high-speed computer, electron microscope, cryogenic laboratories, and so on.

The 800 teachers who have been selected to participate in this first large-scale program of academic-year institutes were chosen from among teachers with at least three years' experience in teaching. Consideration was given to their ability and general aptitude for teaching.

The academic-year institutes sponsored by the NSF are in addition to its larger program of summer institutes.

Tropospheric Scattering Antenna

AT WILSON, N. Y., a 28-foot antenna and sensitive radio receiver, operated by Cornell Aeronautical Laboratory, Inc., of Cornell University, is probing the problems of long-distance transmission of uhf signals in a research program for the Air Force Cambridge Research Center. Uhf signals are normally limited to line-of-sight transmission, but this antenna is picking up that very small part of the signal which is scattered in the troposphere. The 915-mc signal originates at Lexington, Mass., nearly 400 miles away. It is monitored for 48-hour periods each week.

OF CURRENT INTEREST

CAPABLE of spotting an enemy half a mile away in total darkness, mobile radar set is aptly dubbed the "silent sentry." Its power supply is a newly developed fuel cell which directly converts the chemical energy of gases such as oxygen and hydrogen into electricity.

Official U. S. Army photograph

Electricity from Chemical Energy of Gases

THE DIRECT CONVERSION of the chemical energy of gases into electricity—long a dream of scientists and for years a laboratory curiosity—has been accomplished with the development of the first fuel cell capable of producing thousands of watts of power economically. Using hydrogen and oxygen as fuel, the new silent source of power has been developed by scientists at the Research Laboratories of National Carbon Company, Division of Union Carbide Corporation, Parma, Ohio.

First significant application of the new fuel cells is in providing silent electric power for the U. S. Army Signal Corp's new "silent sentry," which was demonstrated at the Association of the U. S. Army's Communications and Electronics Symposium in Arizona. The world's smallest known radar set, a lightweight, portable unit provides mobile Army forces with local combat surveillance of enemy movements despite smoke, darkness, or fog. A battery of fuel cells provides power to operate the radar set at the U. S. Army Electronic Proving Ground at Fort Huachuca, Ariz.

Hollow Carbon Electrodes

"Secret of the new fuel cell's success," Dr. C. E. Larson, National Carbon's research vice-president, said, "is the chemically treated, hollow, porous carbon electrodes through which the gases enter the cell, and which also conduct the electricity produced by the electrochemical reaction."

Designed to work at ambient temperatures, and at approximately atmospheric pressure, the new fuel cell is the first that does not depend on high temperatures or pressures for efficient operation, it was stated.

Production of electricity directly from hydrogen and oxygen in a fuel cell is inherently more efficient than its production in a conventional steam system in which the heat is supplied by burning these same gases. Practical limitations in utilizing all of the heat produced reduce the over-all efficiency of a steam system to approximately 30% or 35%, while a fuel cell, which eliminates the intermediate heat step and converts directly from chemical to electrical energy, has a top efficiency of about twice that figure.

Unlike conventional batteries, fuel cells remain essentially unchanged during their operating life, and produce electric energy from chemical fuels supplied as needed.

Cells have been operating 8 hours a day, 5 days a week for the past year, with no signs of deterioration, it was stated by a firm representative.

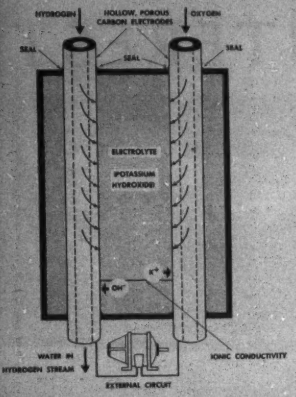
Ability of the new fuel cell to operate at approximately atmospheric pressure has the obvious advantage of eliminating heavy, costly pressure vessels. If increased output is desired, however, it can be obtained by increasing the pressure. For a given cell, higher outputs vary directly with pressure.

Power Output

The efficiency of operation of the new fuel cell depends on how it is used, but the general efficiency range is from 65% to 80% when operated at normal temperatures and pressure. A fuel cell operates most efficiently when no attempt is made to draw the maximum power from a minimum volume. Efficiency is affected by power density—that is, at lower currents, a greater percentage of the chemical energy is converted to electric energy. Research and development to date indicate that the optimum fuel cell design will be one which will produce approximately 1 kw of power from a packaged unit one cubic foot in volume.

The voltage across the electrodes of the new fuel cell is approximately 1 volt, and it is simply a matter of connecting a number of cells in a circuit to get any voltage desired. The amount of electrical current produced by the cell depends on its physical size, so by varying the number and size of cells, many combinations of voltages and currents can be obtained. Basically, the fuel cell is most desirable for high current, low voltage use.

Present designs call for the grouping of a number of specially catalyzed, hollow porous carbon electrodes in a sealed cell containing a solution made of potassium



SIMPLIFIED drawing shows basic fuel cell operation. Hydrogen and oxygen gases enter cell through specially treated hollow porous carbon electrodes contacting a solution of potassium hydroxide. Electrochemical reaction releases electrons accepted at the oxygen electrode thus powering electrical equipment.

hydroxide as the electrolyte. Hydrogen and oxygen enter the cell through hollow electrodes, and diffuse through the porous carbon to the surface, where they come in contact with the electrolyte. At the hydrogen electrode, the electrochemical reaction with the potassium hydroxide produces water and releases an electron that enters the electrical circuit. The electron flows through the external circuit, and returns to the cell at the oxygen electrode, where in the electrochemical reaction of the oxygen and the electrolyte, the electron is accepted. Ionic conductivity through the electrolyte completes the electrical circuit.

A concentric tube design has also been developed, in which one electrode tube nestles within the other, with the electrolyte in between. The tubes are simply made long enough to give the proper cell volume for the current desired.

Fuel Cell's Future

The inherent advantages of the fuel cell make it an ideal source of silent electric power in remote locations where conventional fuels or water power are not available. Military communications systems, mobile power units, and stand-by power plants are but a few of the expected applications.

As a producer of electric energy, the fuel cell depends on a practical and economical source of hydrogen, a gas that at present is quite expensive and requires relatively bulky pressure vessels. Possible hydrogen sources include coal, which yields hydrogen when exposed to steam in the water gas reaction. Ammonia is another possible source, and the catalytic cracking of petroleum products can also produce hydrogen. An inexpensive source of hydrogen is a must if the fuel cell is to compete with conventional power systems as they are known today.

Another possible future use of the fuel cell is in connection with the utilization of both solar and nuclear energy. One of the problems in harnessing the energy of the sun is the storage of power. During sunny periods, the energy of the sun could be used to decompose water into hydrogen and oxygen, for later use in fuel cells. Nuclear energy is known to decompose water, and in present nuclear plants in which the reactor serves only as a source of heat in the conventional steam cycle, efforts have to be made to prevent this decomposition. Perhaps it will work the other way, with nuclear energy directly producing hydrogen and oxygen for fuel cell operation.

DIRECT CONVERSION of chemical energy of gases into electricity has been accomplished with development of the first practical fuel cell. Dr. Karl Kordesch holds one of the specially treated electrodes and is seen examining a fuel cell unit.

Dynamometer Plots Performance Curves Automatically

A 1,000-HP DYNAMOMETER in the research and development laboratories of the Twin Disc Clutch Company at Rockford, Ill., has been automated by Baldwin-Lima-Hamilton (B-L-H) *SR-4* series instruments. (See cover.)

The *SR-4* instrumentation permits the machine to record automatically an entire family of performance curves in the time a single curve could be plotted using a conventional point-to-point dynamometer.

Input torque is measured by an *SR-4* torquemeter, and output torque by an *SR-4* 10,000-pound capacity load cell. These torque-sensing instruments feed data to special xy function plotters or, alternatively, to dial-reading torque indicators.

The function plotters automatically draw performance curves of test units installed on the dynamometer test plate as the giant machine is operated through a series of rapid changes in input speed and horsepower. The dial-reading indicators show the operator, at a glance, conditions at any given moment. With this instrumentation, this test machine outmodes the stop-and-go techniques required of dynamometers equipped with mechanical load-sensing and measuring devices.

The dynamometer consists of six basic units: (1) a 1,000 hp Allis-Chalmers (A-C) 1,775 rpm squirrel-cage type motor, (2) a Dynamatic eddy-current clutch brake unit, (3) a pair of Worthington gear boxes, (4) a B-L-H *SR-4* torquemeter, (5) a test unit cradle with a 14-foot base plate, and (6) a Dynamatic eddy-current absorption dynamometer.

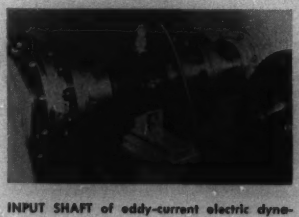
The machine will deliver 1,000 hp to a test unit at all speeds from 900 rpm to 3,000 rpm and will develop 8,000 pound-feet of torque from zero to 900 rpm. It will absorb 17,500 pound-feet of torque at 75 rpm and 20,000 pound-feet of torque at full stall (0 rpm) with a top input speed of 3,000 rpm.

The squirrel-cage induction motor is operated on 2,300 volts by a blower-cooled A-C transformer. Both motor and transformer are equipped with hot-spot indicators and automatic unloading controls.

The Dynamatic eddy-current clutch brake unit may be set to deliver from 15 rpm to 1,800 rpm, with all speeds controlled to 0.5%, or it may be set to deliver a constant torque regardless of speed demanded by the unit on test. The clutch is supplemented by a brake so that rapid changes can be immediately controlled by the operator.

The Worthington gear box is another unique feature. In order to test large torque converters and clutches adequately, the new dynamometer was required to be able to deliver at least 1,000 hp throughout the useful speed range of the machine. Because the A-C induction motor operates at an essentially constant speed of 1,750 rpm, this constant 1,000 hp output at all speeds could be obtained only with some type of geared transmission between the input clutch and the unit on test. Calculations based on requirements dictated the need for a five-speed transmission. As no five-speed, 1,000 hp transmission is commercially available, Worthington was asked to make one.

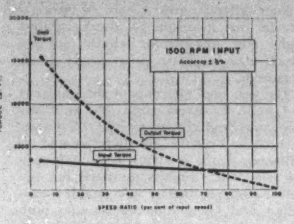
The resulting transmission delivers



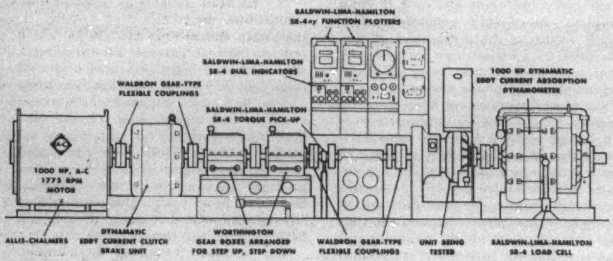
INPUT SHAFT of eddy-current electric dynamometer picks up and transmits to recording instruments rapid changes in input torque.

speed ratios of 1 to 1, 1.8096 to 1 in multiplying series, and 1.3448 to 1 in dividing series. The gear box is arranged so that it can be uncoupled easily, lifted from its mounting plate, turned end for end and recoupled. When this is done the transmission becomes a speed reducer having ratios of 1 to 1.3448 and 1 to 1.8096, thereby providing the required five speed ratios.

Input torque is shown on a manually balanced torque indicator mounted on the central control panel and the torque signal and speed signal can be fed into a xy-function plotter mounted on the panel which automatically plots input torque vs input speed or input torque vs speed ratio.



TORQUE CONVERTER performance chart drawn automatically in 12 seconds by 1,000 hp dynamometer.


BALDWIN-LIMA-HAMILTON SR-4xy FUNCTION PLOTTERS
BALDWIN-LIMA-HAMILTON SR-4 DIAL INDICATORS
WALDRON GEAR-TYPE FLEXIBLE COUPLINGS
BALDWIN-LIMA-HAMILTON SR-4 TORQUE PICK-UP
1000 HP DYNAMATIC EDDY CURRENT ABSORPTION DYNAMOMETER
1000 HP, A-C 1775 RPM MOTOR
ALLIS-CHALMERS
DYNAMATIC EDDY CURRENT CLUTCH BRAKE UNIT
WORTHINGTON GEAR BOXES ARRANGED FOR STEP UP, STEP DOWN
WALDRON GEAR-TYPE FLEXIBLE COUPLINGS
UNIT BEING TESTED
BALDWIN-LIMA-HAMILTON SR-4 LOAD CELL

SCHEMATIC DIAGRAM shows principal operating components of 1,000 hp dynamometer installed in research and development laboratories which produces an entire performance curve in 12 seconds.

according to the choice of the operator. The absorption end of the machine is instrumented to show speed and output torque. Output speed, developed by the unit on test, is indicated in the same way as input speed. The output torque signal from the load cell is fed to a separate function plotter on the control panel which automatically plots output torque against speed or speed ratio. Both input and output function plotters are accurate to within plus or minus 0.5% on both axes.

Service stop and emergency stop controls on the console panel and at six other convenient locations around the dynamometer room allow the motor to be taken off the line and the entire machine brought to a full stop from 3,000 rpm in just two seconds.

Future Meetings of Other Societies

National Council of State Boards of Engineering Examiners, 36th Annual Meeting, Oct 31-Nov 2, 1957. Atlanta Biltmore Hotel, Atlanta, Ga.

International Congress and Exhibition of Measuring Instrumentation and Automation, Nov 2-10, Dusseldorf, Germany.

AIME, Institute of Metals Division, Nov 4-7, Morrison Hotel, Chicago, Ill. AIME, 29 W. 39 St., New York, N.Y.

2nd World Metallurgical Congress, Nov 4-8, Hotel Sherman, Chicago, Ill. W. H. Eisenman, American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio.

EIA (RETMA), Radio Fall Meeting, Nov 11-13, King Edward Hotel, Toronto, Ont., Canada.

National Electrical Manufacturers Association, Nov 11-15, Traymore Hotel, Atlantic City, N.J.

IRE

Mid-America Electronic Convention, K.C. Section, Nov 13-14, Municipal Auditorium Kansas City, Mo. T. V. Anderson, Central Technical Institution, 1644 Wyandotte St., Kansas City, Mo.

New England Radio Engineering Meeting, Nov 15-16, Mechanics Bldg., Boston, Mass. H. H. Dawes, General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

ASA, 8th National Conference on Standards, Nov 13-15, San Francisco, Calif. C. Ainsworth, Technical Director, American Standards Association, 70 E. 45th St., New York 17, N.Y.

NACE, Miami Section, Technical Meeting, Nov 13-16, Key Biscayne Hotel, Key Biscayne, Fla. A. B. Campbell, Exec. Sect., 1061 M & M Building, Houston 2, Texas.

Pennsylvania Electric Association, Fall Meeting, Electrical Equipment Committee, Nov 14-15, Benjamin Franklin Hotel, 9th & Chestnut Sts., Philadelphia, Pa. P. H. Robbins, Metropolitan Edison Company, P. O. Box 542, Reading, Pa.

10th Air Conditioning & Refrigeration Exposition, Nov 18-21, International Amphitheatre, Chicago, Ill. R. H. Israel, Virginia Smelting Co., West Norfolk, Va.

ASME, Annual Meeting, Nov 30-Dec 5, Statler Hotel, New York, N.Y.

Radar-Riding SPARROW I Joins Atlantic and Pacific Fleets

THE FIRST air-to-air guided missile in the nation's arsenal, the SPARROW I already had reached an advanced status before it was officially announced by the Department of Defense early in 1954. The announcement came after seven years of development by the U. S. Navy's Bureau of Aeronautics and the Sperry Gyroscope Company. Adm. Arleigh Burke, Chief of Naval Operations, credited "years of intensive development by the Bureau of Aeronautics and Naval Air Missiles Test Center, and Sperry for the readiness of the fleet with this air-to-air missile system."

More than 100 prototype missiles had been constructed and critically test-flown between 1948 and 1951, including air launchings from Navy aircraft as early as 1949. Evolutionary models, these missiles were the forerunners of the production SPARROW I missiles now in service with the Sixth and Seventh Fleets of the U.S. Navy. Behind the initial, terse announcement of the first air-to-air missile system, is a pioneering project that began in 1946 when plans were made for wind tunnel test, simulator studies, development, design, manufacture, and field testing of three progressively improved missile types: test, experimental, and prototype.

The major operating elements of this weapon system are as follows: (1) an Aircraft carrier which serves as a mobile base and directs a fighter to the vicinity of the target; (2) the fighter squadron; (3) the missile carried by the fighters; (4) the fighter fire control system which indicates the course to be followed by the fighter; and (5) the fighter radar set which transmits the beam which guides the missile, and which furnishes data to the fire control system for determining the course to be followed by the launching aircraft.

A major element of the weapon system, the SPARROW I is a supersonic air-to-air, beam-rider type of guided missile. The missile consists of a fuze and warhead, a source of hydraulic and electrical stored energy, a guidance system and a rocket motor, all packaged in an 8-inch diameter, 12½-foot cylindrical body with a pointed ogival nose. Four variable incidence wings are attached near the center of gravity and

U. S. NAVY personnel operating the test equipment used to check out the effectiveness of the SPARROW I.

are deflected to maneuver the missile throughout its flight. Four fixed tail fins provide longitudinal stability. This arrangement of wings and tail fins is a cruiform configuration and provides for maneuverability in any direction without the necessity of banking the airframe for a turn, as with conventional aircraft. The assembled missile weighs about 300 pounds. Attachment lugs are located on the body to suspend the missile from the launching rack of the carrying aircraft.

Arming the Fighter

The SPARROW I is carried externally under the wings of fighter aircraft which are equipped with airborne guidance radar. Each fighter is armed with four missiles. These are carried by launching racks attached to stub pylons. Typical installations are on the Douglas *F3D-2M Skynight*, the Chance-Vought *F7U-3M Cutlass* and the McDonnell *F3H-2M Demon*. These jet aircraft operate from both carriers and shore bases, and are effective at all operational altitudes against high-speed jet bombers, fighters, and certain missiles.

In tactical flight operations, enemy aircraft are picked up by the airborne radar and SPARROW I missiles are launched by the fighter and controlled by a guidance system that "looks through clouds" and places the missile squarely on the target. Fighter aircraft armed with SPARROW I missiles are successful in attacks against high- and low-altitude aircraft targets which may be flying either singly or in squadrons.

The principal elements of the guidance and control system are: (1) multiaxis gyroscopes and accelerometers; (2) missile antenna and receiver for detecting the intelligence in the guidance beam; (3) missile computing circuits to shape the signals to obtain precise and stable beam riding, and (4) servomechanisms for positioning the wings of the missile as required for maneuvering in flight. These elements are packaged in a number of unitized separate assemblies in order to facilitate manufacture, test, and field servicing. Both the mechanical and the electronic components are packaged to form complete functional assemblies. This greatly facilitates the preparation of specifications on a logical basis for each element, and it simplifies system checkout and maintenance for the missile.

The power supplies for SPARROW I include battery sources for electrical energy and a high-pressure hydraulic accumulator for the mechanical energy required to position the wings. Both supplies are designed with adequate capacity to furnish the energy required for the duration of the flight of the missile. Because the supplies provide power for the guidance and control system, the battery and the accumulator are packaged in the cylindrical section of the missile near the wing-positioning servomechanisms.

Rocket Motor

The rocket motor is the source of energy which provides the thrust that gives the missile the velocity increment over its launching speed. Thrust on the missile in the forward direction results from the reaction of the hot gases ejected at high velocity in a rearward direction. The hot gases are generated by the steady combustion of the high-energy fuel of the rocket motor.

The motor is packaged to form a smooth cylinder that is a section of the missile's body. It consists of three major components; namely, the case, the propellant grain, and the igniter assembly. The case is a thin-walled metal cylinder with an attachment mechanism to the forward section of the missile, and with a nozzle which directs the high-velocity gases aft. The high-energy propellant uses solid concentric grains with a plastic base which burn uniformly, and thereby gives a steady thrust to the missile. The chemical composition of the grain provides an oxidizing agent, and therefore burning rate essentially is independent of altitude.

The igniter assembly fits into the forward section of the motor and is triggered by an electric impulse. The grain of the motor is fired in a fraction of a second by action of the igniter and a large uniform thrust is generated immediately. Suitable safety and arming circuits are provided with the igniter assembly so that the live motors can be stored and handled safely by ordnance personnel at shore installations and aboard ship.

The warhead assembly for SPARROW I includes three major elements; namely, (1) the safety and arming mechanism which provides positive safety of life for ground, shipboard, and flight personnel under all conditions of environment and handling; (2) the fuze which detonates the warhead at target interception; and (3) the warhead which includes an igniter and explosive assembly which when detonated will kill the target. These elements are packaged in a section of the cylindrical body and form a separable assembly to facilitate manufacture, and to provide safe field handling and storage.

The SPARROW I missile is launched when the pilot of the fighter aircraft closes the firing switch. This action sends to the missile an electric pulse which ignites the rocket motor. The resultant thrust propels the missile forward relative to the launching rack and the missile quickly attains a speed significantly greater than that of the carrying aircraft. By motor burnout, which occurs within seconds after launching, the missile's velocity is twice to three times the speed of sound. When attacking an enemy target, the missile either is launched singly or several missiles are launched rapidly in sequence.

Accordingly, it is said that the missile "rides the beam" and SPARROW I is classified as a beam-rider missile. Because the guidance beam is positioned precisely in the direction from the launching aircraft to the target, the missile is guided along a trajectory which leads to an interception even under evasive action. Destruction of the target is effected by the lethal action

SPARROW I missile leaves launching rack at speed that outstrips fighter plane on its way to radar tracked target.

FIGHTER with four SPARROW I missiles attached to underslung launching racks on stub pylons.

of the fuze and warhead when the missile intercepts the target.

United States Navy and Marine Corps pilots have demonstrated the high reliability and deadly accuracy of the SPARROW I Weapon System by hundreds of missile launchings against target drones. The lethal warhead has blasted out of the sky all types of targets including high-speed jet aircraft and missiles.

Liquid-Hydrogen Bubble Chamber Developed

Development of a liquid-hydrogen bubble chamber more than 60 times as large as any now in use is being conducted by the University of California Radiation Laboratory (UCRL) assisted by the National Bureau of Standards (NBS). The bubble chamber is being constructed to operate with the Bevatron, the 6 billion electron volt particle accelerator at UCRL. D. B. Chelton, D. B. Mann, and B. W. Birmingham of the NBS Cryogenic Engineering Laboratory at Boulder Colo., are working on the project, which involves many difficult and unique cryogenic engineering problems.

High-energy nuclear physics progress during the past 20 years has been made possible largely by improvements in particle accelerator design, coupled with corresponding advances in the art of particle detection. The bubble chamber, a vessel filled with a transparent liquid which can be so greatly superheated that an ionizing particle moving through the liquid will start violent boiling, initiating growth of a string of bubbles along its path, was devised to overcome some of the shortcomings of the cloud chamber, photographic emulsions, and other detection equipment available for high-energy experiments. The bubbles, photographed a short time later, while they are still very small, give a clear picture of particle tracks.

However, the operation of a bubble chamber with liquid hydrogen involves complex cryogenic problems. At normal atmospheric pressure, hydrogen boils at 20 degrees Kelvin. Its critical temperature is 33 degrees Kelvin and its critical pressure is 13 atmospheres, above which no liquid phase is possible. For a hydrogen filled bubble chamber to operate successfully, the temperature and pressure must be between these values.

Successful hydrogen bubble-chamber operation has shown that for best results the liquid should be maintained in the subcooled state at about 27 degrees Kelvin and 6 atmospheres. To make the chamber sensitive to ionizing particles, the liquid must be superheated, and this is accomplished by suddenly reducing the pressure to 2 or 3 atmospheres. A significant expansion of the liquid hydrogen volume is required for the superheating operation because of the compressibility of the liquid. After photographs of particle tracks are taken, the cycle is completed by compressing the chamber liquid and returning it to the subcooled state. Refrigeration is required to maintain the chamber liquid at a constant temperature because the irreversible superheating process adds energy to the liquid hydrogen.

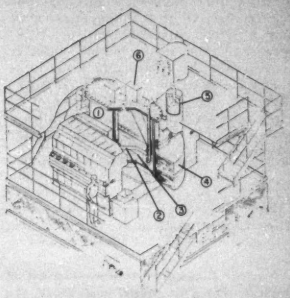
One-half liter and eight-liter liquid hydrogen bubble chambers have been constructed and operated during the past two years at UCRL. The NBS assisted UCRL with some of the cryogenic design aspects of these smaller chambers, and these early successes led to the belief that a very large liquid hydrogen bubble chamber was feasible. Consequently, a chamber having a volume of about 550 liters (15 by 20 by 84 inches) was planned for use with liquid hydrogen and is now being constructed. It is scheduled for operation early in 1958.

One of the advantages of the bubble chamber as a high-energy particle-detection device is that it can be pulsed (i.e., superheated) at the same rate as the accelerators. However, this pulsing, as previously mentioned, is irreversible and adds energy to the liquid. Thus, refrigeration is required if a constant bubble-chamber temperature is to be maintained. The refrigerator for use with the 550-liter hydrogen chamber must remove energy at 27 degrees Kelvin at the rate of about 1,800 watts when the Bevatron is operating at the maximum pulse rate of 10 per minute.

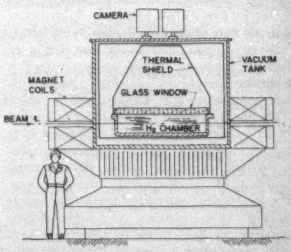
The hydrogen refrigerator will utilize the Joule–Thomson process and operate at a pressure of 2,000 psig. An amount of 200 standard cubic feet per minute of hydrogen gas will be circulated in the refrigerator. When there is no refrigeration demand, the unit can be operated as a liquefier producing 60 liters per hour of liquid normal hydrogen.

Superheating the liquid hydrogen in the chamber will be accomplished by suddenly expanding the hydrogen vapor in equilibrium with the liquid. Recompression will take place less than 30 milliseconds later when hydrogen vapor maintained at liquid-nitrogen temperature (77 degrees Kelvin) is admitted. If the expansion and compression could be accomplished in the liquid phase, the energy input per pulse would be reduced as well as the refrigerator requirements, but a complex mechanism operating at 27 degrees Kelvin would be required. The vapor expansion system is desirable because it will operate external to the chamber, thereby eliminating a low temperature mechanism. It can then be serviced without requiring a warm-up of the bubble chamber.

Whenever possible it is desirable to avoid warming up the bubble chamber because the large glass window must be



BUBBLE CHAMBER and magnet assembly perspective drawing showing (1) vacuum tank, (2) 5-inch thick glass viewing window, (3) liquid hydrogen chamber, (4) magnet, (5) bubble chamber super-heating system, and (6) cameras.



CROSS SECTION of proposed bubble chamber and magnet now under development by the NBS and the University of California Radiation Laboratory.

PATTERNS produced by events involving fundamental particles in a large hydrogen bubble chamber were photographed in the Radiation Laboratory of the University of California, Berkeley.

cooled and warmed slowly in order to minimize the possibility of breakage. It has been estimated that about one week will be required to warm the chamber to ambient temperature and cool it again to the operating temperature of 27 degrees Kelvin.

High-energy physicists are anxiously awaiting the completion of this large bubble chamber. Of great interest to scientists was a recent announcement by UCRL physicists that small bubble chambers have shown the existence of a fusion reaction catalyzed by mesons. It is hoped, therefore, that successful operation of the large chamber will make possible a better understanding of fundamental nuclear physics.

Nuclear Developments

Nuclear Propulsion Studies. The use of nuclear power to propel missiles of the future is under serious investigation, and will be further advanced with a powerful new atom smasher which went into use recently at the Lockheed Nuclear Laboratory at the Missile Division's research and development center located at Stanford University's industrial park, Palo Alto, Calif.

The 3-million-volt Van de Graaff positive-ion accelerator is the largest such device in use within the aircraft industry, and the first of its type on the West Coast.

Investigations will cover the fields of nuclear structure, reactor design, radiation shielding design, and material damage, as well as others.

Dr. R. D. Moffat, who will be in charge of the machine's operation, explained that it could produce nuclear radiation under controlled conditions which permit great accuracy of measurement. He said that the ion beam emerging from the accelerating tube consists of high-velocity hydrogen or helium nuclei which interact with the atomic nuclei of the target material. These processes will be studied in order to understand better the structure of the target nuclei and the nature of its interaction with the ion beam.

The accelerator will be made available to other scientific organizations on a commercial basis.

Test Radiation Detectors. U.S. Army scientists are testing a new series of radiation detectors which have been placed in tanks, balloons, and underground. The units were developed at the Army Signal Corps Engineering Laboratories, Fort Monmouth, N. J. The new equipment keeps a continuous record of radiation hazards in the test area after a blast. The information is stored in well-protected underground recorders until the area can be entered safely. These facts could be used to prepare radiation charts for combat strategy.

One type of spotter being used is designed to pop up from the ground in a fashion similar to a periscope. This device measures the radiation at various distances from the blast site. It is kept underground to protect the instrument from the fierce atomic shock wave. A split second after detonation, an automatic air gun jolts the unit into detection position.

A Sherman tank has had a similar radiation probe installed to determine how close to ground zero such an armored vehicle can be without danger to its crew.

Another set of instruments have been attached to a balloon which was tethered at 1,000 feet to measure radiation hazard in the air. The balloon itself burns instantly from the nuclear heat flash, but instruments have time to send readings through coaxial links to the underground recorders.

In addition to battlefield tactics, civilian defense officials can use the data for planning against possible enemy nuclear attack. (Picture on page 1031.)

22nd Semiannual Report. The U.S. Atomic Energy Commission (AEC) has made public its report concerning activities at Argonne National Laboratory.

The first civilian electric power producing reactor was commissioned and has supplied up to 5,000 kw to the Laboratory at Lemont, Ill.

The courses of the International School of Nuclear Science and Engineering continue. Students from 41 nations and the United States have been taught thus far.

Many experiments with variations on the Experimental Boiling Water Reactor (EBWR) have been carried out. Some of the final designs on these have been completed within the six months covered by the report.

International Atomic-Energy Agency. A report proposing a program for the first year of operation of the International Atomic Energy Agency has been made by the Preparatory Commission of the Agency. Its basic objective "is the first attempt on a world-wide basis to face the challenge and opportunity of the peaceful uses of atomic energy." Recommendations were taken up at the first General Conference which was held in Vienna. These considered the relationship of the Agency with the United Nations (UN) and other world organizations, where to locate the headquarters of the group, and the structure and administration of the Agency.

Radiation Study by UN. Working from UN Headquarters in New York City, scientists from 15 nations are making a worldwide study of the possible hazards involved in the increasing uses of atomic energy and the precautions which should be taken to counteract them.

These scientists are members of the UN Scientific Committee on the Effects of Atomic Radiation, reflecting one side of the UN's interest in the powerful force locked in the atomic nucleus.

Medical uses, effects on future generations, fall-out hazards, and international co-operation, are some of the points covered by the group.

Power Station in Italy. The Government of Italy and the International Bank for Reconstruction and Development have agreed to co-operate in sponsoring a study which will lead to the construction of a large nuclear power station in southern Italy.

Japanese Reactor. The first atomic energy reactor for the Far East, located near Tokyo, Japan, has been operating since August. This research reactor was set up for the Japan Atomic Energy Research Institute and is a "solution type" unit which uses uranium in a water solution as its fuel. It has a 50-kw power level and will be used to conduct extensive investigations into nuclear sciences as well as to perform other research including medical and agricultural studies.

Inter-American Symposium. The fact that Latin America as well as other countries in the Western Hemisphere are keenly interested in the peaceful uses of atomic energy was demonstrated by the enthusiasm of the 110 delegates from 19 countries who attended the recent "Inter-American Symposium on the Peaceful Uses of Atomic Energy" at Brookhaven.

Venezuela is one of the more advanced countries in Latin America as was demonstrated by the impressive exhibit of its Institute of Neurology and Brain Research (IVNIC), which is responsible for the country's atomic research program.

The main conclusions which emerged from the symposium was that in addition to being useful from a technical standpoint, the greatest benefit came from the interchange of information among the delegates themselves, thus establishing a new basis from which Inter-American cooperation could be achieved. The key problem at the moment was found to be the need for training adequate numbers of skilled men in the field of nuclear power. One step toward solution of part of the problem has been put into operation with the assistance of the AEC. The University of Puerto Rico has established a special school for nuclear education where instruction will be in Spanish, thus enabling students from all the American

EXPERIMENT in which the transmission of a neutron beam through a gas sample will be measured is set up by Dr. Martin Walt (left) and Dr. R. D. Moffat.

Republics to enroll for instruction. The University will have a "swimming-pool" type research reactor by 1958 or early 1959.

Standardizing the Peaceful Atom. The first step toward world standardization for peaceful use of nuclear energy was taken by the delegates from 13 countries at a meeting of the International Organization for Standardization (ISO) in Geneva, Switzerland, recently.

The first meeting of the ISO Technical Committee 85 on Nuclear Energy outlined six areas of work as:

(1) Development of a tri-lingual glossary of terms applicable to nuclear energy and based on work already done in various countries.

(2) Development and approval of a warning symbol for use wherever danger from ionizing radiation is present.

(3) Adoption of units pertaining to nuclear energy, developed by the International Commission on Radiation Protection and the International Commission on Radiological Units.

(4) Development of symbols required for drawings pertaining to nuclear equipment and installations.

(5) Development of international recommendations relating to measurement of radiation and protection against radiation.

(6) Development of internationally acceptable guides for safe design, operation, and maintenance of nuclear reactors.

The United States has 15 delegates who were accredited by the American Standards Association.

Work already done by national and international organizations will be taken into account by the technical committee to avoid unnecessary duplications.

Peak Power Linear Accelerator. The Massachusetts Institute of Technology (MIT) and Harvard University are constructing a 6 billion volt electron synchrotron for which one of the highest peak power linear accelerators in the world is being built by Applied Radiation Corporation, Walnut Creek, Calif. The unit is to serve as an injector for the synchrotron.

The 20-mev traveling wave linear accelerator will provide 5-mw peak output power, and special design techniques will allow unusually precise control of the injected beam's energy and frequency.

The linear accelerator embodies several innovations. No organic gaskets are employed throughout the vacuum system and the entire unit from electron gun to output beam analyzer is baked at 400 C. Such thorough outgassing, in conjunction with operating vacuums in the 10 mm of mercury range, minimize r-f breakdowns and allow exceptional operating stability.

The Cambridge accelerator will be located on the Harvard campus housed in a covered trench. It will be managed by a joint committee of scientists and administrators from both schools. Funds are being provided by the AEC as part of its program supporting research in high energy physics. The Cambridge group anticipates research in the production of strange new mesons and hyperons, photoproduction studies of pions, proton and antiproton pairs, muons and nucleons at higher energies, and studies of electron structure.

Revised Uranium Handbook. A revised edition of the popular prospector's handbook entitled, "Prospecting for Uranium" is available from the Superintendent of Documents, U. S. Government Printing Office. The revision includes an enlarged section on the geologic occurrence of uranium based on the large amount of new information developed during the growth of the uranium industry. It also includes the latest AEC uranium price circulars and an up-to-date compilation of laws and regulations affecting uranium mining.

Yankee Plant Construction Permit. The AEC has filed notice of proposed issuance of a permit to the Yankee Atomic Electric Company (YAE) of Boston, Mass., for construction of a large-scale nuclear power plant on the Deerfield River at Rowe, Mass.

An association of 12 utilities from all 6 New England states, the company plans to build and operate a pressurized, light-water cooled and moderated reactor and generating equipment capable of producing 110,000 kw of electricity from the initial reactor core, and 134,000 kw from a subsequent loading.

Application has been made for a 40-year license to operate the reactor. Under the Power Demonstration Reactor Program, the company will have AEC assistance in research and development up to $5 million and waiver of fuel use charges for a period of five years. The AEC has allocated 6,052 kilograms of contained U-235 for use over the period of the license. This is a net figure—transfers of U-235 from the AEC to YAE, less returns of U-235 in recoverable fabrication scrap and spent fuel elements.

History and Development of ETR. The Engineering Test Reactor (ETR) grew out of overwhelming demands on its predecessor, the Materials Testing Reactor (MTR), and is located next to the MTR at the National Reactor Testing Station in Idaho. The MTR was the first high power test reactor for testing materials to be used in nuclear power plants, and its facilities quickly became overloaded. A board appointed by the AEC's Division of Reactor Development recommended that the Idaho operations office design and construct an ETR using AEC funds. Thus, the ETR was built at a cost of approximately $14 million, which compares favorably with the $15 million AEC estimate.

The ETR will provide irradiation facilities urgently needed in development of reactor components for military and civilian power reactors. It will perform engineering tests on fuel elements, and its main purpose is to provide large experimental facilities with high neutron fluxes, thus supplementing test reactors which are already in use. The ETR will provide a large number of in-core test facilities, ranging in size from 3- by 3- by 36-inch to 9- by 9- by 36-inch holes. It is housed in a gas-tight building. The heart of the project is a light-water cooled and moderated reactor fueled with enriched uranium having a thermal rating of 175 mw. The core consists of a square array of 49 fuel elements, 16 control rods, and numerous penetration for experiments. Precautions have been taken to safeguard the security of the installation (only those with official business are allowed in), and the health and safety of personnel.

WESCON Highlights Seen

Two examples of advanced electronic defense units were featured at one of the displays at the Western Electronic Show and Convention which was held recently in San Francisco, Calif.

One was a scale model of the ATLAS, a missile guidance computer of the U. S. Air Force. The display illustrated how the computer fits into the Intercontinental Ballistic Missile system. The other unit displayed was an operating radar antenna from the U. S. Navy's *AN/ASB-1* high-altitude bomb director system.

On exhibit at the Burroughs Corporation Electronic Instruments Division booth was a core tester that applies a series of switching and nonswitching pulses which, in conjunction with a pulse calibrator, allows the precise measuring of output amplitude and switching time through output voltage displayed on an oscilloscope.

A new instrument, the Optimeter transfer storage counter, has the unique ability to sample almost any type of high-speed information without stopping the count or losing the original data.

SCIENTISTS of the U.S. Army in radiation clothing install special equipment in tank to determine how close vehicle can be to atomic blast without danger to crew.

Test Facility for High-Power Pulse Transformers

A new testing facility—a pulse testing modulator—has been installed by the specialty transformer department of Westinghouse Electric Corporation. The new equipment is used to test insulation and response characteristics of high-power pulse transformers used primarily with klystron and magnetron loads. It is said to be the most powerful and versatile facility of its kind in the world.

The new testing modulator is used to simulate the input to the pulse transformer under test as well as its output load conditions during operation. The pulse test modulator simulates loads ranging from 1 to 30 mw, but can be modified for loads up to 50-mw peak. Top peak voltage for the load tests is 200 kv. Special loads can be provided for higher voltages if necessary. An approximate duty ratio (ratio of average to peak power) of 0.002 can be achieved.

For no-load tests, a wide selection of output impedances are available, ranging from 2 to 100 ohms. The wide range of impedances is made possible by changing plug-in network connections and using auxiliary network transformers. A unique water-load rheostat is used to load secondary of pulse transformer when running load tests.

Main advantage of the water load is its smaller physical size with resulting reduced capacitance to ground. The water load can be varied from 500 to 2,000 ohms by changing salt concentrations in the solution.

In addition to the wide range of output impedances and loads available, more than 100 pulse-width steps from 0.5 to 8.0 μsec can be produced. With addition of a single network coil, pulse width can be extended to 20 μsec. Pulse repetition rate is limited only by the two *FC 1257* hydrogen thyratron switching tubes, fired alternately, that also control the peak output power. The d-c power available is higher than that controlled by these tubes since it is anticipated that peak power ratings of tubes will be increased at a later date.

Flexibility of modulator design permits easy rearrangement of facilities to permit testing of other radar transmitter components. Charging reactors, pulse forming networks and switch tubes can be tested within the power range of the equipment.

Under all conditions, the pulse top is flat within 5%. If either fast rise or flat top are of particular importance, the networks can be trimmed at the expense of the other characteristics of the wave shape. The test facility has four basic components: power supply, modulator, load and test booth, and desk-type control console.

CONTROL CONSOLE for pulse test modulator. During tests, interior of pulse modulator and test room are darkened to permit detection of corona or flashovers.

Terminal City Has Never-Ending "Daylight"

What is believed to be the world's largest installation of blanket floodlighting has been completed at New York (N.Y.) International Airport (Idlewild). The unique lighting installation provides never-ending "daylight" for the airport's Terminal City—a 655-acre area that includes airline terminals, restaurants, a hotel, retail shops, extensive parking areas, and a huge botanical garden.

The installation has specially designed General Electric (GE) mercury quartz vapor lamps and floodlights.

The Port of New York Authority, which operates the airport, decided a general blanket type illumination was essential and that the desired effect could not be achieved with conventional lighting fixtures. At that point, T. M. Sullivan, chief of the Authority's Aviation Planning Division, and lighting designer A. H. Feder called in lighting experts from GE's outdoor lighting department, Hendersonville, N. C., and large lamp department, Cleveland, Ohio.

A totally new lighting concept was created to bathe the 6 million square feet of Terminal City in virtually glareless light and GE was commissioned to develop a suitable lamp and floodlight based on studies and specifications made by Mr. Feder.

DESIGN ENGINEER tests new GE quartz mercury vapor lamp that is in use at Terminal City.

The result was a 1,500-watt mercury quartz vapor lamp, rated at 81,000 lumens, which provides approximately three times as much illumination as a 1,500-watt incandescent floodlight. To house the powerful lamp, GE developed a special 54-pound luminaire that measures 22 inches in diameter, has a 20-inch door glass, and incorporates some of the best features of the company's *L-69A* general purpose floodlight. The new luminaire has been designated the *L-101*.

For Terminal City, 338 of the floodlights were mounted in clusters of 6, 8, 10, and 12, atop 43 specially designed 75-foot-high pylons which are located on approximately 320-foot centers. Illuminating engineers estimate that approximately 3 times as many floodlights and 12 times as many standards would have been required to illuminate the area by conventional means.

The lighting system was designed to provide flexibility in targeting individual light beams for uniform coverage in selected areas, while providing a highlight pattern in other areas. Because of this, the maintained level of illumination is expected to vary from a minimum of about 1.5 footcandles to a maximum of approximately 5 footcandles.

Port Authority officials point out that the lighting system is to provide "aesthetic nighttime beauty" from both land and air as well as adequate illumination. In an average month, some 3,300 flights carrying approximately 150,000 passengers arrive at and depart from the airport. In addition, thousands more reach the terminal by car. Consequently, the Port Authority specified that the new lighting system must provide adequate illumination and unusual beauty from the air as well as on the ground. This is believed to be the first large-scale installation where aerial appearance has played a major role in the design of a lighting system.

The result obtained by the GE installation presents a striking view for air travelers with varying lighting levels providing a sequence of lights and shadows on buildings and landscape, turning the terminal area into a shining nighttime jewel in a sea of darkness. For the motorist, a series of gently winding, well-lighted approach roads lead into Terminal City.

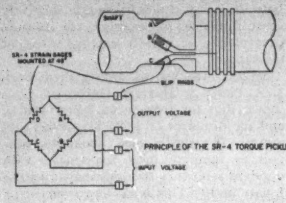
Torquemeters Used To Test Car Performance

Electric strain-gauge torquemeters have enabled automotive engineers at Ford's Dearborn Research and Engineering Center to take engine and transmission testing off the road and into the laboratory. A new indoor testing method they developed is cheaper, faster, and more accurate.

The new method, using Baldwin *SR-4* torquemeters as the torque sensing and measuring instruments, permits engine and transmission loads, under rapidly changing conditions, to be measured in the laboratory instead of being measured on the road.

The method, called inertia-wheel testing, gives performance data that not only is more accurate and less costly than road testing, but also yields more information than can be obtained by dynamometer tests.

Basically, the inertia wheel is a specially constructed fly wheel. To test an engine on it, the wheel is preloaded so that its rotating mass is equivalent to the weight of the particular car model for which the engine is designed. The engine under test, together with its transmission, is coupled to the preloaded inertia wheel



FOUR STRAIN GAUGES, for SR-4 pickup, are connected in a Wheatstone bridge circuit with the points of the bridge wired to slip rings mounted on the shaft. The SR-4 pickup and torquemeter are made by the Electronics & Instrumentation Division.

instead of to the drive shaft of the car. When the engine and transmission accelerate, the mass of the wheel offers the same resistance to changes in engine speed as a moving vehicle would.

With these torquemeters attached to both engine and transmission, engineers can measure even the most rapid changes in the "car's" performance with less than 2% error.

The torquemeter used consists of four *SR-4* strain gauges bonded to a steel shaft 18-inches long and connected in a Wheatstone bridge circuit. The points of the Wheatstone bridge are connected to slip rings mounted on the shaft, and a non-rotating brush assembly, mounted on the test equipment base, carries input and output voltage to and from the bridge circuit.

The engine, itself, is mounted on jacks and is equipped with a complete exhaust system including muffler and tailpipe. The fan and air cleaner are also installed on the engine.

The automatic transmission is mounted on a headstand, with a short jackshaft to accommodate the *SR-4* torquemeter between the engine and transmission. An inductor, mounted between the transmission and the inertia wheel, prevents creep before an acceleration run and slows the engine and transmission to idle after a test run.

At the start of an acceleration test run, the engine is operated until the oil and water temperatures are stabilized. Then the inductor is used to stop the output shaft, so that the operating conditions simulate that of a stationary vehicle with the engine idling.

The inductor is then turned off and the throttle is suddenly opened wide. The throttle is held open until the speed of the output shaft reaches 4,400 rpm. At this point, the engine is braked by the inductor and the throttle is closed.

Engineers at the Dearborn research center report that the oscillograph traces obtained with *SR-4* torquemeters clearly show such engine conditions as roughness, hesitation, missing, rough shifts, and runaway shifts.

With its *SR-4* equiped inertia wheel, a wide variety of engine and transmission variables and their influence on performance have been studied, such as, cam timing, vacuum versus centrifugal distributors, air-conditioning compressors, initial spark advance, carburetor jet size, distributor type and calibration, carburetor secondary throttle springs, competitive transmissions, competitive engines, transmission shift points, exhaust systems, and flywheel mass.

In contrast with dynamometer testing —which the inertia wheel supplements but does not replace—inertia-wheel testing

OSCILLOGRAPH and bank of carrier amplifiers record performance results of hydraulic transmission with a Lincoln V8 engine under simulated highway operating conditions.

allows the transient factors present in vehicle operation to be reproduced in the laboratory.

Sled-Mounted Mobile Substation

A mobile substation believed to be the first ever built on skids instead of wheels, is supplying power for a strip coal mine in Kentucky.

The unit was built at General Electric's Power Transformer Department at Pittsfield, Mass., for the River Queen Coal Company, Greenville, Ky.

The substation is mounted on a sled made of 24-inch steel I-beams, heavily braced and angled up at both ends for pulling by tractor. It was especially designed to provide a low center of gravity and a 24-inch clearance for pulling over rough terrain with slopes up to 30 degrees. The whole unit weighs 14½ tons and includes a forced-oil air-cooled transformer rated 3,750 kva, 34,500 to 4160Y/2400 volts; switchgear, lightning arresters, and accessories.

It is being used at River Queen's strip mine to supply power for a 55-cubic-yard electric shovel.

Towers are erected to carry the high-voltage lines to the sled substation, and heavy cables laid on the ground carry power from the transformer's secondary to the shovel.

The River Queen mine is operated by the Peabody Coal Company, St. Louis, Mo., and owned jointly by Peabody and the W. G. Duncan Coal Company.

"Signal Enhancement" Increases Radar Power Effect

New FM-CW radar system developed by Columbia University, New York, N.Y., scientists and engineers at the University's Electronics Research Laboratories for the U. S. Air Force raises the strength of a radar signal reflected from an aircraft or a missile "to an unprecedentedly high level" without any actual increase in the power used. This was described as being of particular significance for radar installations in regions like the Arctic, where it is extremely difficult to supply fuel and other facilities for producing large amounts of power.

Scientists associated with the program said that recent military developments, particularly the use of very high speed aircraft and missiles, had resulted in a need to increase radar ranges. To allow time for defensive action, such targets must be detected at very much greater distances than those sufficient for detecting and tracking propeller-driven planes. Inasmuch as the strength of a radar echo decreases as the fourth power of the distance to the target, older radar techniques would achieve increased range only through substantial increases in the power of the radar. For example, if it is necessary to double the range at which an aircraft can be spotted, such methods would require a 16-times increase in power. A 10-times increase in range would require a 10,000-fold increase in power.

In addition to the effects of increased aircraft and missile speeds, it was explained that jet bombers and high-speed missiles are very poor reflectors of radar signals compared to multi-engined propeller-driven aircraft. This also leads to a need for greater radar power.

The Air Force–Columbia University program utilized fundamental principles of communication theory to achieve its

SUBSTATION mounted on sled weighs 14 tons. This unique mobile unit provides power for electric shovel at mine. It can be pulled over rough terrain quickly to new job site.

GE Newsbureau Photo

results. Dr. R. I. Bernstein, associate director of the Electronics Research Laboratories, and J. H. Bose, associate in electrical engineering and former assistant to Major E. H. Armstrong, explained that much of the theoretical basis for the work had been established by numerous researchers following World War II.

The problem solved by the Columbia group was to devise a means of generating and processing a signal with characteristics so distinct from atmospheric noise that it could be reinformed, amplified, and detected.

Heart of the system called ORDIR (omnirange digital radar) is based on a prior knowledge of the characteristics of the reflected signal. This is achieved through precise control of the carrier modulation so that the injected characteristic returns in the proper time-phase relationship. Through a method of storage of the reflected signal energy and a recovery system in the receiver employing a technique of "coherent integration" the signal is greatly enhanced and made to "stand still" long enough in the proper time-phase relationship so that the injected characteristic can be detected and amplified.

The achievement was hailed by Dr. J. R. Dunning, noted pioneer atomic physicist and dean of the Columbia School of Engineering as "an outstanding breakthrough" in radar since the start of World War II and the early British work."

The new Columbia analog computer and its other components perform the basic tracking and computing required in an over-all system which receives data from long-range radars, tracks potential hostile planes, and then automatically directs interceptors to the oncoming target for the kill. This latter project was also carried out in the Electronics Research Laboratories under Air Force sponsorship. The new defense system is the first operational ground control intercept system of the Air Force to work on the principle of electronic automation, furnishing signals which are automatically incorporated into the fire control system of the intercepting aircraft and thus automatically guiding its flight to "a terminal phase." It is now being produced in quantity by the GE Heavy Military Electronic Equipment Department, Syracuse, N. Y.

Experimental 60-Kc Standard Frequency Broadcast

Opening up several interesting applications, some of which are already in use, is an experimental 60-kc standard frequency broadcast, begun July 1, 1956, at the Boulder (Colo.) Laboratories of the National Bureau of Standards (NBS). A. H. Morgan, chief of the Radio Broadcast Service Section of the NBS Radio Standards Laboratory, is supervising the experiment.

The NBS has been broadcasting standard frequencies since 1923, when radio was in its infancy and very few people owned radio receivers. Through the years, higher power and more frequencies have been added until at present the NBS standard frequency broadcasts are on six high frequencies (2.5, 5, 10, 15, 20, and 25 mc) at WWV, Beltsville, Md.; and on three (5, 10, and 15 mc) at WWVH, Maui, Territory of Hawaii. Up to 10 kw are radiated on some of the frequencies. Specialized radio receivers for these broadcasts have been commercially available for many years.

Measurements by the Boulder Laboratories and others have revealed that the regular standard broadcasts at high frequency are subject to changes in frequency as they travel away from the transmitting antenna. These changes are caused by disturbances in the propagation medium, and the errors introduced may at times amount to ± 3 parts in 10^7. This is sufficient to make these h-f broadcasts unsuitable for many applications, e.g., rapid assessment of drift in the manufacture of high-precision quartz resonators, intercomparison of frequency standards, and accurate time measurement or synchronization of events at two or more locations which may be separated by thousands of miles. Two techniques are now available for precise frequency calibration, but both have limitations. One such technique, employing time comparisons, requires expensive terminal apparatus and a measurement time that extends over 1 to 10 days or even longer. The other makes use of a ground wave near the transmitter. This introduces an error in propagation of less than 1 part in 10^{11}, but is useful only to about 20 miles from the transmitter. At distances greater than 20 miles, the sky-wave must be used and calibrations made by means of this wave are not adequate for the ever-increasing precision required by an expanding science and technology.

The principal reason for studying standard frequency broadcasts at frequencies below about 100 kc is to determine a practical method whereby the radio propagation errors are minimized and users may accomplish high-accuracy frequency comparisons in a shorter measurement time. Users also need a better time or phase reference to measure precisely the time between events which happen in relatively short intervals, for example, to measure the velocity of rapidly moving waves or objects.

INTERIOR of tuning house near NBS antenna base, showing tuning coils used in efficiently transferring power from transmitter (about 3,000 feet away) via overhead transmission line to antenna.

Several investigators, among them Prof. J. A. Pierce at Harvard University, have shown that for frequencies below 100 kc and for distances of 5,000 kilometers and greater, it requires only about 10 minutes to compare local frequencies with standard frequency transmissions to within 1 part in 10^9. This is an improvement of more than 100 over what can be obtained at h-f. Prof. Pierce has carefully determined that a high-accuracy standard frequency service can be given for all the world on a single very low frequency from a single high-power transmitting station.

The experimental broadcast on 60 kc, although on low power, has already presented several intriguing possibilities. With the co-operation of Prof. Pierce, it has been possible to compare the NBS primary frequency standard, broadcast on 60 kc, with the British standard which is broadcast on 16 kc and 60 kc, to an accuracy of comparison which is better than two parts in one billion. This has been done almost continuously since the broadcasts began in July 1956.

One of the lesser known services is the broadcasting of a musical tone of standard pitch—middle "A" at 440 cycles per second—over its shortwave stations WWV and WWVH. These broadcasts make standard pitch available day and night throughout the United States and over much of the world. Since a shortwave receiver is all that is needed, easy access to standard pitch is thus provided for piano tuners and amateur and professional musicians, as well as for makers of musical instruments.

A 600-cycle tone is also broadcast. This, together with the 440-cycle tone, is used by scientists, electronics engineers, and manufacturers in the measurement of short intervals of time and for calibrating instruments and devices that operate in the audio and ultrasonic frequency ranges. Both the 440- and 600-cycles tones are obtained from an electronic, crystal-controlled oscillator and are accurate, as transmitted, to better than 1 part in 100 million.

The two frequencies are broadcast alternately, starting with 600 cycles on the hour for 3 minutes, interrupted 2 minutes, followed by 440 cycles for 3 minutes and interrupted 2 minutes. Each 10-minute period is the same except that WWV is off the air for 4 minutes beginning at 45 minutes after each hour; and WWVH is silent, in addition, for a 34-minute period each day beginning at 1900 Universal Time (9 a.m. in Hawaii or 2 p.m. E. S. T.).

The National Bureau of Standards maintains the A equals 440 cycles standard as the one on which general agreement has been reached. The musical merits of any particular standard are, of course, outside its province.

Previous standards of pitch were defined in terms of the frequency of a particular tuning fork or bar, or the length of a specified vibrating air column (organ pipe). Inasmuch as the sound frequencies generated by these devices vary with the surrounding temperature, it is necessary

to specify the temperature at which comparisons with these standards should be made.

In changing over to Standard Pitch, little or no alteration is necessary in adjusting instruments tuned to the older standard. Instruments tuned by string tension and the open vibrating air columns of pipe organs present no problems at all. Woodwinds can be corrected partly by the tuning adjustment of the instrument and partly by the breath control of the player; and changes required in the reed stops of the organ are within the range of the instrument's tuning adjustments.

Solid-State Devices for Microwave Radio Relays

Predictions of the impact of solid-state electronics on modern technology and the announcement of the development of a new microwave radio relay system using many of the new solid-state devices were made at a European Symposium on Radio Links which took place in Rome recently. Dr. M. J. Kelly, president of Bell Telephone Laboratories and M. B. McDavitt, director of transmission development of the Laboratories, presented papers at the Symposium, sponsored by the Italian National Research Council.

Mr. McDavitt's paper described a microwave radio relay system which has been under development at Bell Telephone Laboratories and which is called the "TH" System. This system takes advantage of much of the advanced solid-state and other electronic technology developed at Bell Laboratories in recent years.

It makes highly efficient use of the overcrowded radio spectrum, promising to increase more than three times the information-handling capacity of radio relay systems occupying comparable spectrum space.

The television programs could be either black-and-white or color for home reception or color theater programs.

In addition to handling television, telephone, and radio services, the new system will provide an increased capacity for transmission of "digital" information used in teletypewriter and data transmission. The system will have extremely fast switching equipment for bringing in alternate equipment or channels in case of component failures or atmospheric disturbances.

Citing the "TH" system as an example of the impact of solid-state physics on telecommunications, Dr. Kelly in his keynote address)declared that the "fundamental approach" was bringing about the new era in electronics.

The "TH" system is designed to operate in the 5,925-6,425-mc microwave band. It provides a total of eight 10-mc broadband channels in each direction, plus two narrow-band 0.5 mc channels for order wire and alarm facilities. Six of these eight bands may be in use at any particular time, the other two being held in reserve as protective channels to be switched into service automatically if needed.

Each broad-band channel can provide a number of services: 1,860 voice channels with 4-kc spacing; a black-and-white or color television signal plus 420 voice channels; or a broad-band television signal such as might be required to transmit a color television picture of theater-screen size. Various other services such as teletypewriter, facsimile, and data transmission can also be readily accommodated.

An r-f output of 5 watts, frequency modulated, is radiated at each transmitter. This output is provided by a newly designed traveling wave tube which has a gain of 30 db. The traveling wave tube is driven by a frequency converter, which boosts the i-f of 74.1 mc to the final transmitted frequency. Conversion is accomplished by a newly developed gold-bonded diode which can provide gain, if desired, but is operated at a low bias to give a uniform impedance over the i-f range and so gives neither gain nor loss. This is the first use in a system of a diode modulator without inherent loss.

Isolation between forward and reflected signals at various points in the system is provided by microwave ferrite isolators, each of which has an insertion loss of 0.25 db or less in the forward direction, and at least 27 db in the reverse direction.

A microwave ferrite switch is employed to switch rapidly and automatically between regular and standby critical equipment in case of equipment failure. Switching time is less than one millisecond.

The horn reflector antennas and round waveguide now being installed in relay towers can be used simultaneously for the new "TH" system at 6,000 mc, the present transcontinental *TD-2* at 4,000 mc, and the new short haul *TJ* system at 11,000 mc. Special filters are employed to separate the various signals.

Adjacent channel signals are alternately horizontally and vertically polarized to provide isolation between channels of 20 db more than would otherwise be available. This permits adjacent channels to be placed much closer together, and aids greatly in increasing the utilization of the available frequency spectrum.

Silicon power rectifiers are employed in the power supplies, thus contributing greatly to reliability. Because of the high efficiency of these rectifiers, power consumption and heat dissipation are both appreciably reduced.

Activities of Other Organizations

National Committee for Utilities Radio—The NCUR in answering the Federal Communications Commission (FCC) on several Dockets, with reference to Docket No. 11991 opposed an amendment which specified that the use of any frequency may be restricted as to hours of operation. It was urged that all channels in the 152–162 mc band be continued available to the Power Radio Service. Docket No. 11990 which is an amendment to establish a new Local Government Service seems feasible, but needs further study, it was stated by the NCUR representative. The comment on Docket No. 11997 was to the effect that, at the present rate of increase, a more realistically equitable allocation of bands be made. NCUR has an Operating Practices Manual and a Technical and Policy Guide Manual available which cover various points of interest to the membership with regard to their relationship to FCC rules and regulations. NCUR will continue to oppose any proposed changes which restrict or endanger the use of radio by the electric, gas, water, and steam utilities.

Joint Military–Industry Symposium—Guided missile reliability is the topic of the annual meeting sponsored by the Office of the Assistant Secretary of Defense for Engineering and the Chief of the Bureau of Aeronautics, Navy Department, from November 5 through 7.

The 1957 Guided Missile Reliability Symposium will be held at the Naval Air Missile Test Center at Point Mugu, Calif. Papers on component problems, mathematical treatment, plant techniques, and testing techniques will be presented which are not classified, or have been cleared through the proper authorities. Preprints will be available.

Standardization Seminar—A 5-day seminar on industrial standardization is to be conducted by Dr. John Gaillard, management counsel, at the St. Francis Hotel, San Francisco, Calif., from November 18 through 22.

EIA (former RETMA)—The Membership and Scope Committee has been appointed by the President W. R. G. Baker according to the formula previously adopted. The members for the fiscal year 1957-58 are: H. J. Hoffman (chairman), L. F. Muter, R. S. Alexander, S. R. Curtis, D. W. Gunn, W. J. Morlock, A. D. Plamondon, Jr. (ex officio), J. D. Secrest.

American Nuclear Society—At its 3rd Annual Meeting, the ANS elected its 1957-58 officers as follows: L. J. Haworth, president; T. G. LeClair, vice-president; M. A. Schultz, treasurer; J. G. Beckerley, editor; seven new Directors at Large elected consisted of J. C. Bugher, Karl Cohen, W. K. Davis, M. C. Leverett, W. B. Lewis, J. R. Menke, Sidney Siegel, and Clarke Williams; and W. W. Grigorieff, executive secretary, who continued in office.

American Standards Association—Eight American Standards on electronic components have been approved by the ASA. Seven were developed by the EIA (C83.9—C83.15) and submitted to the ASA for approval. The specifications cover tolerances, performance and test requirements for waveguides, capacitors, cable connectors, rheostat, coaxial cables, and dimensions for panels used to mount electronic equipment. The Institute of Radio Engineers developed the standard on pulse quantities (C16-28). As the national co-ordinating body and clearinghouse for engineering, industrial, and consumer standards, the ASA is a federation of 118 associations, societies, and organizations as well as 2,300 companies. The individual standards are available at varying nominal cost from the ASA, 70 E. 45 St., New York, N. Y.

National Science Foundation Grant to MIT—Translation of three Russian-language electronics journals into English will be made possible by $70,000 grant

given by the NSF to the Massachusetts Institute of Technology. The project was an MIT Research Laboratory of Electronics proposal for the purpose of making available to American engineers information about the progress and methods in Soviet electronics research. American libraries and researchers will be able to subscribe to the English versions of the three journals, *Radio Tekhnika i Elektronika, Radio Tekhnika,* and *Elektrosviaz.*

Report of TASO Shows Significant Activity

In 1956, the Federal Communications Commission (FCC) requested the television industry to set up an organization to study the various engineering problems involved in the allocation of frequencies, or channels, for television broadcasting. The industry responded by establishing the Television Allocations Study Organization (TASO) with headquarters in Washington, D.C., and financed co-operatively by the television broadcasting and manufacturing industries.

To carry on its work, TASO has formed six panels of television engineers and has assigned to each the study of one aspect of the allocations problem. The functions of these panels are indicated by their names. Panel 1 on Transmitting and Panel 2 Receiving Equipment are compiling and studying data on the performance of transmitters; repeater transmitters; transmitting and receiving antennas; and transmission lines, receivers, and converters. Panel 3 on Field Tests is studying the operation of television receiving equipment in the field. Panel 4 on Propagation Data is making a thorough analysis of existing information on the transmission of vhf and uhf waves and is compiling new data on the propagation of signals from television stations across the country. Panel 5 on Analysis and Theory has the task of fitting all of the information obtained by the other panels into a consistent picture which will show all engineering aspects of the allocations problem. A sixth panel on Levels of Picture Quality has recently been formed upon the recommendation of Panel 5. Its assignment is to specify what constitutes a good television picture in the presence of interference such as noise, co- and adjacent-channel interference and ghosts.

One of the interesting activities of TASO Panel 4 is being carried on by crews who are measuring the field strength of signals transmitted by television stations. Two station wagons owned and equipped by the Association of Maximum Service Telecasters which is one of the groups sponsoring TASO are each equipped with an hydraulically operated extensible mast which raises measuring antennas to a height of 30 feet. Inside each station wagon are vhf and uhf field strength meters, Esterline-Angus recorders, and storage battery operated power supplies. To date, these station wagons have been in the Norfolk, Wilkes-Barre, Scranton, New Orleans, and Baton Rouge areas where extensive surveys have been made, using techniques specified by Panel 4. Similar equipment has been furnished by CBS Television. Other organizations, including Westinghouse Broadcasting Corporation and KTTV, Los Angeles, are also expected to furnish similar equipment and crews.

While Panel 4 is making measurements of field strength, field test crews from Panel 3 are to study television reception in homes in the same areas. It is recognized that the ultimate aim of television broadcasting is to provide good pictures in the home and, therefore, the correlation between signal strength, as measured by field strength meters, and received picture quality must be established. Preliminary field studies have been made in Fresno and New Orleans and the work soon will be extended to all areas where TASO propagation measurements are made.

One other interesting problem is that of obtaining information regarding the type of receiving installations to be found throughout the country and the performance of receivers in the home as contrasted with the performance of receivers in the manufacturers' laboratories. Panel 3 has felt from the start that such information is best known to the men in the television service industry who have day-to-day experience in the installation, maintenance, and repair of television receivers and receiving antennas. Therefore, a rather extensive questionnaire dealing with these problems has been prepared and will be sent to a large number of television servicemen. It is hoped that a high percentage of replies will be received, as it is believed that only the servicemen can give the information which is needed regarding conditions in regions of high- and low-signal strength, in vhf, uhf, and intermixed areas, in mountainous and flat terrain, in urban and rural communities. The serviceman represents a vast reservoir of valuable information which has been tapped much too infrequently. TASO and the FCC are optimistic about the quantity and the quality of information which can be obtained from this source.

Ferroelectric Material Discovered

Intensive exploration in the field of ferroelectrics has resulted in the discovery of a new ferroelectric material by B. T. Matthias at Bell Telephone Laboratories. Known chemically as triglycine sulphate, the material has a rectangular voltage hysteresis loop and other desirable properties which make it very promising for switching circuits and memory devices.

The most popular ferroelectric crystal previously investigated is barium titanate. Triglycine sulphate is superior in that it has a much lower coercive field (220 volts per cm), thus permitting switching with a lower voltage. Its polarization results in a lower output pulse when switched, but the size of the pulse can be increased by increasing the area of the switching electrodes.

Triglycine sulphate is stable chemically and does not decompose when exposed to moisture or to the atmosphere. It has adequate mechanical strength to permit handling in thin sheets. Large single crystals can be grown quite easily, and a number of large-area slices can be cut from each crystal.

Repeated switching does not cause any fatigue in triglycine sulphate, as it does in barium titanate. And a given area will retain a given polarization indefinitely without any deterioration. Although heating beyond the Curie point causes the material to lose its ferroelectric properties, these properties are regained in full when it is cooled.

The Curie point of this new material (point at which it loses its ferroelectric properties) is about 47 C. However, by replacing some of the hydrogen atoms with deuterium, easily accomplished when the crystal is grown, the Curie point can be raised to 60 C.

Switching time, an important characteristic in any switching or memory device, depends on the characteristics of the material and the switching voltage. It appears that switching times of the order of one to two microseconds can easily be attained with this new material.

Electrodes can be applied to a slice cut from a single crystal by evaporating thin strips of metal on each side of the slice, the strips on one side being perpendicular to those on the other. Using this technique, 30 or more strips per inch can be applied, resulting in a memory or switching device capable of storing 900 or more "bits" of information on a square inch of crystal. A number of such slices can be assembled in a relatively small volume, resulting in a very compact assembly.

Thickness of the slice can be from 5 to 10 mils, depending on the available pulsing voltage and the desired output. Switching can be accomplished with about 20 volts, a value easily obtained with transistorized circuitry. The actual power required for switching is very small, thus minimizing internal heating.

Acoustico-Thermal Laboratory Completed

Designed to aid engineers in lowering sound levels and examining thermal characteristics of transformers, a new acoustico-thermal laboratory has been added to existing $25 million facilities at General Electric's (GE) Medium Transformer Department, Rome, Ga.

It is believed to be the first laboratory ever constructed to combine facilities for rapid, accurate experimental and production testing of both thermal and sound characteristics of medium transformers. It will be used to test both dry type and liquid-filled transformers with ratings up to 10,000 kva.

For thermal tests, heat can be removed from the 2,250-square-foot test chamber at the rate of 2,000 Btu per minute without a draft. Accurate testing of transformer sound characteristics down to 40 db is also possible.

The new facility has been established primarily "to aid in generating information on transformer sound characteristics which will enable us to get better acoustical performance from our transformers," it was stated.

The Laboratory, part of GE's $500 million program of expansion and modernization for the years 1956 through 1958, was designed to provide all necessary conditions for accurate sound testing—regulated power supply, low ambient sound, and a simulated free field.

Heavy masonry construction excludes extraneous external noises to help insure low ambient sound, and serrated acoustical insulation in the form of glass-fiber bats prevents internal sound reflection. Doors are pneumatically sealed.

Exhaust fans and a duct system make possible the draftless removal of 2,000 Btu per minute to prevent gradual ambient temperature rise during thermal tests.

A regulating autotransformer—composed of an induction regulator and an autotransformer—provides precisely regulated power and insures good waveform and the wide range of volt–amperes combinations needed for experimental testing.

Instrumentation for current, voltage, power, temperature, sound, vibration, and harmonic analysis is housed in a 250-square-foot control room which adjoins the test chamber.

A specially designed springless flatcar on which transformers may remain during tests provides efficient transfer of units from the manufacturing area into the 33-foot-high anechoic test chamber.

This laboratory is the fifth GE facility directed to sound research and development on utility-type transformers. The company built its first such facility in 1938 at Pittsfield, Mass. Since that time, two others in Pittsfield and one in Schenectady, N. Y., have been built. The Rome Laboratory, however, is the first to devote its entire research and testing facilities to improving the company's medium transformer line.

Forward Scatter Link Above 2,000 Mc

The successful operation of a complete "forward scatter" communications link in frequencies above 2,000 mc has been established by the Research and Development Division of Allen B. Du Mont Laboratories, Inc. According to Du Mont engineers, the path length of the new Du Mont link is 124 miles, and transmission and reception are at 2,180 mc. The transmitter is located at Cedar Grove, N.J., and the receiver is at Somers, Conn., near the Massachusetts state line.

The increased problems of the crowded radio spectrum make communications in these low microwave frequencies of particular importance in both military and commercial communications, it was pointed out. Furthermore, more information can be transmitted in these higher frequencies within a relatively smaller segment of the spectrum. Also, at these higher frequencies it is possible to produce more effective radiated power from a particular sized dish.

The transmitter dish of the Du Mont system has an 18-foot diameter and is mounted on a 24-foot tower. It is connected by waveguides to a 1-kw transmitter utilizing an air-cooled EIMAC klystron tube. The transmitter is capable of 72 voice channels with a bandwidth of 2.5 mc.

Use of the 1-kw klystron provides a reasonably priced, high-power, commercial package, according to Du Mont spokesmen. A unique feature of the transmitter is a magnetic amplifier regulated power supply for the klystron, which requires no tubes.

An interesting problem in choosing the transmission path was presented by the Palisades on the west side of the Hudson River. By directing the signals through a gap at Sparkill, N.Y., the horizon for the signals was extended 10 additional miles.

Reception at Somers, Conn., utilizes two 10-foot dishes on 25-foot towers. The specially designed, highly sensitive 52-tube dual diversity receiver operates reliably on a signal strength of 8 microvolts.

Research and Technological Advances Made in West Germany

The annual report on scientific and industrial research and technological advances in electrical engineering and electric equipment made in 1956 in the Federal Republic of Germany shows that electric machines and drives trended toward the development of motors with smaller dimensions and better starting and running conditions.

A series of synchronous miniature motors were made that would be suitable for connections to 50-cycle a-c at 100-127 volts or 220-250 volts. Some small squirrel-cage motors have been developed which can be used with all voltages, having a new type of sintered bearings, hardened and polished shaft, and a 20-centimeter-gram starting torque. A group of miniature 3-phase induction and a-c motors with revolving cage frames have been made which give high output and efficiency. Also, there were a series of self-regulating generating sets with extremely high switch-over speeds, suitable for starting units in jet-propelled aircraft, radar equipment, and X-ray apparatus.

Because of the increased importance and need for outdoor substations for medium voltages, the electric equipment industry has developed a number of new transformers and rectifiers. Of these, a series of air-tight maintenance-free voltage transformers have been made which are oil insulated, unipolar, and which have a nitrogen filling in the corrosion-proof housing around the top that absorbs the expansion of the oil filling. Trolley current converters, germanium heavy-current rectifiers, flat miniature rectifiers in plastic casings, and miniature vibrators are some of the developments in addition to those already mentioned.

The increase of switching speeds and efficiency and the capability to transmit high voltages over long distances induced such developments as tiny power switches designed for 10 and 20 kv with rated breaking capacities of 250 mva, multiple free jet circuit breakers for 110, 220, and 380 kv with 4 and 8 series-connected nozzles designed to take the full test voltage without additional air gaps.

In the low-voltage switchgear and relays field, the following developments are a few that were included in the report: a new motor protective switch for 3 kva, 500 volts, with removable overload releases suitable for 2.5 to 25 amperes; "Thermoclick," a thermal time contactor for efficient protection of single-phase motors; and an electronic time relay which is suitable as a slow-acting relay switch, time remote-control switch, and impulse transmitter.

The high-frequency and telecommunications equipment contributions to the electrical industry consisted of an automatic long-distance call rate recorder, a 23-channel impulse modulated directional wireless station for microwaves in the 15-cm band, and an ultrashortwave miniature transmitter (weight: 740 grams).

Radio Web To Scan the Skies

Of all the components proposed to date for air navigation and traffic control systems, the pattern set up by Radio Web is the only one that solves the collision avoidance problem by extending the pilot's range of vision electronically. This system combines the inherent advantages of a grid co-ordinated system with a visual presentation that is free of line-of-sight limitations. Radio Web offers a radio scanning feature that is truly revolutionary in its implications, it was stated recently by Stavid Engineering, Inc., U. S. Highway 22, Plainfield, N. J.

Navigation is easier because Radio Web permits the aircraft to follow any route, preselected or otherwise. Traffic control is eased inasmuch as the system allows ground control stations to monitor continuously, from takeoff to landing, all traffic within a given zone, and selectively to communicate with any aircraft within the zone. Collision warning is virtually eliminated by the fact that Radio Web electronically extends the pilot's vision, thus providing the means for minimizing to the point of elimination all risk of air collision.

False and ambiguous information is eliminated. Simple equipment reduces possibility of failure, enhances ease of maintenance, and allows for additional standby systems as needed.

Military aircraft, commercial airlines, general aviation, helicopters, and surface vessels can make use of the development. The basic feature of Radio Web is the use of scanning lines to explore space in a series of successive channels. When a scanning line encounters a co-operating aircraft, it causes a responder to emit a position signal from the aircraft. The ground display of aircraft responder signals constitutes a control map showing position, direction, speed, and altitude of all co-operating aircraft. Information is presented in a form readily utilized by either a human controller or an automatic control device. Means are available for relaying instructions manually or automatically to any co-operating aircraft.

In any control area, position accuracy is governed by two consecutive transmitters

which are selected to generate the spot scanning control pattern. Inasmuch as the web pattern is not uniformly fine, the two governing transmitters are arranged to locate the finest and most regular portions of the web over areas of relatively high traffic density. The fineness of the web is the main limitation on the accuracy of position information. Location information is never more accurate or less accurate than plus or minus half a channel. For a zone of 360,000 square miles, the maximum relative error is about one-half mile, which is adequate for ground control of low density traffic. Altitude is measured by an aneroid barometer preset at standard pressure. A filtering system in the ground receiver directs each aircraft's position signal to an appropriate visual display for its particular altitude range. With the use of a calibrated display screen of the proper persistence, it becomes a simple matter to determine the speed and direction of any given aircraft. Automatic control systems derive their signals from the motion of the position spot.

Four 100-kw transmitters arranged in a square beacon an area of 360,000 square miles. Nine such areas would cover the continental United States. This French development is being further refined to meet the extrapolated requirements of American military and civilian aviation.

Alloys Tested by High-Temperature Optical Strain Gauge

Testing of materials will never become routine as long as new materials are developed and older ones are improved. This is particularly true in the case of alloys designed for 1,200 and 1,250 F operating temperatures. Where do you find delicate instruments to measure physical properties of alloys at such temperatures? In some instances, the building of an instrument to do the job involves almost as much work as the development of the alloy itself.

Engineers of the Westinghouse materials engineering department adapted for high-temperature service, a standard optical gauge used for measuring strains at room temperature.

The small instrument roughly 1½ inches long by ¾ inches wide by ⅝ inches high consists of a metal framework to hold two tiny mirrors, one stationary and the other movable. The mirrors are mounted on blocks of Refractaloy (registered trademark) alloy, which have one knife edge that contacts the sample. In operation, the gauge is clamped to the metal surface, a beam of light is aimed at one mirror, reflected to the other mirror and then back to light source, where a scale indicates the angle of the return beam of light. When the sample is heated to test temperatures, the movable knife-edge rotates slightly, changing the mirror angle and, in turn, the light beam return angle. Since there is no mechanical linkage between the strain gauge and the measuring device, an extremely high degree of accuracy is possible. With proper calibration, changes as small as 0.00002 of an inch can be detected.

The chief difficulty from a materials standpoint in adapting the room-temperature gauge to a high-temperature gauge was the mirror surfaces. A successful combination consisted of silver brazing a ⅛ by $\frac{5}{16}$ inch strip of 30-mil-thick platinum to the Refractaloy knife edge blocks. Even at 1,250 F, the platinum stays bright and reflective and the 0.00002 of an inch accuracy is now almost as easy as it was at room temperature.

Short Exposured High-Speed Photography

Multiple-frame photography of events occurring at high speed with exposures as short as one hundred-millionth of a second is possible with the use of a new tube under development by the RCA Electron Tube Division, it was revealed recently.

Called an image converter, the new tube has electrostatic focus, a grid which functions as a shutter, and a deflection system which can produce as many as five separate screen images at one time, it was stated. Development of the tube was sponsored partly by the University of California under Atomic Energy Commission (AEC) contract. Many of its features embody the results of earlier research and development sponsored by the U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va.

The operating principles of the image converter in high-speed photography are simple. The event or action is focused on the photocathode of the tube by means of a fast objective lens. The light striking the photocathode produces electrons which are attracted at high velocity toward the fluorescent screen at the opposite end of the converter. In their passage, the electrons first encounter a fine metal mesh called a gating grid. This grid may be charged either to repel the electrons emerging from the cathode or to permit their travel toward the screen. This grid is also used to focus the electrons on the screen.

After the electron beam passes the gating grid, it is directed through a small aperture to a set of deflecting electrodes. Design of these electrodes makes it possible for the beam to be deflected over a wide angle without serious distortion or loss of resolution.

The electron beam energy is converted by the phosphor screen into actinic radiation. The screen is especially prepared with a very fine-grain phosphor and is backed with aluminum to increase light output. Under normal operating conditions, the tube can provide an increase in radiant energy emitted from the screen of as much as 25 times the radiant energy incident on the photocathode.

Equipment for Proving Speech Transmission Theories

The transmission of speech over wires is one of the most challenging problems in the field of engineering. The sound coming out of a telephone receiver should be a facsimile of the sound that goes into the transmitter. But, telephones may be separated by thousands of miles and the speech that enters the telephone at one end may have to pass through a number of circuits and many types of terminal and repeater equipment before it emerges from the receiver at the other end.

What happens, then, when an engineer comes up with a new theory for improving the voice quality or the efficiency of a telephone line? If, for instance, he wants to introduce but one new element into the relay system that will permit more messages to be sent over that same line, how can he be sure that the over-all system will work according to his theory? How can he test all of the variables of distance, time, and performance characteristics of equipment known at present and anticipate their effect on his proposed changes? The obvious method—modifying the scores of relay stations according to the new theory and conducting actual tests on an existing full-length telephone line, would not only be fantastically expensive, but might even disturb telephone service over parallel lines. An alternative method—constructing a laboratory test model that would duplicate conditions on the cross-country line, is scarcely less expensive, especially in the light of modifications that might be necessary to convert it for use in future tests.

New equipment designed at Bell Telephone Laboratories and developed by the Modac Division of Airborne Instruments Laboratory now permits Bell researchers to prove complex theories of speech transmission without building expensive test models.

Bell Laboratories researchers developed a theory they considered might eliminate the setting up of these costly and time-consuming masses of experimental equipment. If they could get a piece of equipment that could convert their theories into computer information, a great saving of time and money could be effected in testing these theories. Dr. Henry MacDonald and Dr. M. V. Mathews, of Bell Telephone Laboratories, brought their problem and the suggested solution to Thornwood, N. Y., where Modac is located. As a result, the record and playback unit was conceived and is being manufactured. This equipment reduces experimental theories on speech and speech systems to a magnetic tape and evaluates them by actually examining electrically the synthesized output of the IBM (International Business Machines) computer, as different variables and engineering concepts are introduced.

J. D. Mountain, director of Modac, in explaining the equipment, stated that the theory testing system couples a magnetic tape record and playback unit with a high-speed electronic computer. In sound research, exact conditions of the proposed telephone circuit—the functions of the existing equipment plus the individual function of the equipment to be introduced—are fed onto magnetic tapes that record all of the functions as electronic impulses. This equipment, together with a converter, combines the impulses into digits which are fed to the computer. In the computer, the digits are run through a myriad of equations

simulating the circuit, and a final answer —in numerical form—is produced. This answer is then fed back into Modac equipment where it is converted into electronic impulses which exactly duplicate those of the proposed new circuitry. The machine then reproduces the voice through a speaker, exactly as it would sound if the voice had traveled any proposed distance.

To illustrate this laboratory short-cut, Axel Jensen, director of visual and acoustics research of Bell Telephone Laboratories, speaking before the NARTB (National Association of Radio and Television Broadcasters) Engineering Conference in Chicago on coding and decoding speech messages, gave an interesting demonstration. He let his listeners hear simple sentences, which had been recorded by the Modac machine onto magnetic tape.

These sentences were then encoded onto the IBM digital tape and transformed by an IBM *650* into punched cards. These cards, in turn, were fed to an IBM *704;* onto tape; into a translator; and, finally, they were put on magnetic tape which, when played, could be compared with the original speech.

Computer Directs Enemy Bomber Interception

A type of analog computer developed by the personnel in Columbia University's Electronic Research Laboratories performs the basic tracking and computing required in a new air defense device designed to receive data from long-range radars, track potential enemy aircraft, and direct defending interceptors to the enemy target.

The new device is the first operational ground control intercept system of the U. S. Air Force to work on the principle of electronic automation, furnishing signals that are automatically incorporated into the fire control system of intercepting aircraft and, thus, automatically guiding its flight to a terminal phase. If desired, the signals may instead be given verbally to the pilot. Previous systems provided signals which could only be relayed to interceptor fighters by voice commands.

In this application, the computer is used to solve the "intercept problem" automatically. It forms the major part of the *AN/GPA-23* Computing Tracking Group of the ground control system, which is known informally in the Air Force as the "Ragazzini computer" or the "Ragatrack."

The computer, as well as the other components, of this *AN/GPA-23* were developed in the School of Engineering, initially under the direction of Prof. J. R. Ragazzini, and subsequently under the direction of Prof. L. H. O'Neill.

In recognition of Columbia's work in connection with the device, the General Electric Corporation (GE), which is producing the unit in quantity for the Air Force, has commended the Laboratories as "a leading contributor to the nation's air defense capability."

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ASTM STANDARDS ON RUBBER PRODUCTS. Published 1957 by the American Society for Testing Materials, (ASTM), 1916 Race St., Philadelphia 3, Pa. 826 pages, 6 by 9 inches, paper. $5.25. Among the topics covered in this compilation are automotive and aeronautical rubber, packing and gasket materials, electrical protective equipment, insulated wire and cable, latex foam, nonrigid plastics, and rubber adhesives. Of the more than 150 standards included, 32 are new or recently revised.

ENGINEERING PROPERTIES AND APPLICATIONS OF PLASTICS. By G. F. Kinney. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1957. 278 pages, 6¼ by 9¼ inches, bound. $6.75. The various plastics are described separately and more or less in the order of increasing complexity. A unified treatment, emphasizing the fundamental nature of plastics, permits the principles, concepts, and terminology to be established in the simpler cases, and is utilized in treatment of the more complex materials.

EPOXY RESINS. By Henry Lee and Kris Neville. McGraw-Hill Book Company, 330 W. 42nd St., New York 36, N.Y., 1957. 305 pages, 6¼ by 9¼ inches, bound. $8. Theoretical and practical information on the chemistry, preparation, and applications of the various classes of epoxy resins. The applications include potting of electrical components, insulation in corrosive environments, coatings, sandwich construction, adhesives, and piping. References are listed at the end of each chapter.

THE GENERAL THEORY OF ELECTRICAL MACHINES. By Bernard Adkins. Chapman & Hall, Ltd., London, England, 1957. 236 pages, 5¾ by 8¾ inches, bound. 45s. An advanced textbook which will also be of use to electrical machine designers, and system and control engineers. Covering both d-c and a-c machines and their operation, the book is intended to lead the student from the general principles and methods of analysis common to all kinds of electrical machines to the nature and performance of particular machines.

GUIDED WEAPONS. By Eric Burgess. The Macmillan Company, 60 Fifth Ave., New York 11, N. Y., 1957. 255 pages, 5½ by 8½ inches, bound. $5. This is a general introduction to the subject. It is of interest to engineers entering the field of guided missile design as well as to the layman who wants to learn the fundamentals, historical and technical, on which guided weapons are based. In addition to dealing with technical features such as the power plant, the propellant, and guidance systems, the book discusses the wartime development of missiles and some of the problems of producing reliable weapons for defense.

INDUSTRIAL RECTIFYING TUBES. Published 1957 by N. V. Philips Gloeilampenfabrieken, Eindhoven, Netherlands. 116 pages, 6¼ by 9¼ inches, bound. $2.15. Discussion of the construction and operation of hot-cathode, gas-filled rectifying tubes and their uses in battery chargers, motion picture projectors, d-c arc welders, and for general industrial purposes. Data on specific Philips' tubes and a selection chart are included.

A MANAGEMENT GUIDE TO ELECTRONIC COMPUTERS. By W. D. Bell. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1957. 403 pages, 6 by 9¼ inches, bound. $6.50. Addressed to executives who do not have an engineering background, this book discusses in nontechnical language the over-all electronic data processing system, components, programming, the present state of computer development, and questions of obsolescence, maintenance, cost, and system selection. A specific plan to assist a company interested in acquiring a system is outlined, and the experiences with electronic equipment of eight companies are described.

MICROWAVE MEASUREMENTS. By E. L. Ginzton. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1957. 515 pages, 6 by 9¼ inches, bound. $12. This thorough treatment of the basic forms of electrical measurements in the microwave region of the electromagnetic spectrum provides a background for all common measurements as well as for some of the more specialized applications. The principal subjects treated are generation of laboratory signals; detection and measurement of microwave power; the measurement of impedance, wavelength, and frequency; representation and measurement of microwave circuits; and resonant cavity characteristics. The book has been written as a text for graduate students and as a reference for engineers.

NACHRICHTENTECHNISCHE FACHBERICHTE. Volume 1, 1955—Halbleiterdioden und Transistoren, 42 pages, DM 3.60. Volume 2, 1955—Rauschen, 124 pages, DM 6. Volume 3, 1956—Informationstheorie, 118 pages, DM 22. Volume 5, 1956—Probleme der Halbleitertechnik, 64 pages, DM 12. Friedrich Vieweg & Sohn, Braunschweig, Germany. 8¼ by 11½ inches, paper. Four groups of papers presented at meetings of the VDE (German Society of Electrical Engineers). These brief but highly technical presentations respectively cover various specialized aspects of transistor design; discuss the conditions leading to noise in electronic equipment and ways of avoiding it; treat information theory from various points of view—mathematical, physiological, technical, and linguistic; and deal with a considerable number of selected problems of immediate interest in the field of semiconductor engineering. English abstracts are provided for the information theory group, and English titles are given for the transistor papers.

NUCLEAR ENGINEERING. Edited by C. F. Bonilla. McGraw-Hill Book Company, 330 W. 42nd St., New York 36, N.Y., 1957. 850 pages, 6½ by 9½ inches, bound. $12.50. This graduate-level text, prepared by a group of 12 experts, presents fundamentals in concise handbook style and discusses more advanced aspects of the subject in detail. Comprehensive bibliographies are included. Chapters of particular interest are those on flow of fluids, thermal-stress analysis and mechanical design, and one on the legal aspects of nuclear power.

PHYSICS. By Erich Hausmann and E. P. Slack. D. Van Nostrand and Company, Inc., 120 Alexander St., Princeton, N.J., fourth edition, 1957. 722 pages 6¼ by 9¼ inches, bound. $8. This fourth edition of a standard college textbook has been reorganized to emphasize the contributions of the great scientists to the thinking of their time, but fundamentals have not been sacrificed. There is a rearrangement of some of the older material for more effective teaching. A new chapter on solid-state electronics has been added and there are revisions in the material on heat, wave motion, and light. The chapter on radiation and atomic structure has been rewritten to bring it up to date.

PHYSICS FOR SCIENCE AND ENGINEERING. By R. L. Weber, N. W. White, and K. V. Manning. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1957. 618 pages, 7½ by 10¼ inches, bound. $8. In providing a text designed specifically for the technical student, the authors have restricted the treatment to a practical explanation of the basic principles of mechanics, heat, sound, light, electricity, and magnetism. The application of these principles is effectively demonstrated by the accompanying problems. A brief section is devoted to nuclear physics, including a cutaway representation of a nuclear power plant.

THE SCIENCE OF ENGINEERING MATERIALS. Edited by J. E. Goldman. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 528 pages, 5¾ by 9¼ inches, bound. $12. Based on a series of lectures at Carnegie Institute of Technology in 1954 on the impact of solid-state science on engineering education, this book serves as a broad outline of this science which makes possible the development of improved and new engineering materials for specific engineering applications. The transistor is cited as an example of such development. The six sections in the book are: the structure of matter; metals and alloys; surfaces, magnetism,

and magnetic properties; semiconductors and dielectrics; and noncrystalline materials.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

AMERICAN STANDARD PRACTICE FOR PROTECTIVE LIGHTING. Designed to assist plant officials responsible for guarding against trespassing, theft, and sabotage, this booklet has been published by the Illuminating Engineering Society (IES). The report treats protective plant lighting as separate from lighting for industrial production and provides descriptive and application data for a wide variety of outdoor lighting equipment, including types of light sources; gives lighting specifications and recommendations for specific areas; covers circuiting; and illustrates with drawings, diagrams, and charts numerous protective lighting problems. IES was the sponsor of "American Standard Practice for Protective Lighting," but an indication of the scope of its information may be found in the organizations represented on the American Standards Association Sectional Committee. These include: AIEE, American District Telegraph Co., American Society of Safety Engineers, Association of American Railroads, Association of Casualty and Surety Cos., Edison Electric Institute, National Association Mutual Casualty Cos., National Bureau of Standards, National Electrical Manufacturers Association, National Safety Council, including four bureaus of the U.S. Government. Copies are available at 50¢ each for single copies from Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N.Y. Quantity prices upon request.

ANNALS OF THE INTERNATIONAL GEOPHYSICAL YEAR. The records of the International Geophysical Year (IGY) are being published for the special committee for the IGY by Pergamon Press of London, New York, and Paris. The general editor of the Annals is Sir H. S. Jones, and the editorial advisory board consists of V. V. Beloussov, L. V. Berkner, W. J. G. Beynon, C. Chapman, A. Danjon, G. Laclavere, V. Laursen, P. Lejay, J. van Meighem, M. Nicolet, Y. Ohman, A. H. Shapley, J. A. Simpson and J. Wordie. With over 60 participating countries, the IGY will be mainly concerned with those earth phenomena the understanding of which requires continued simultaneous observation of several associated properties of the earth and sun. Published in journal form, the Annals will record the history, organization, programs and methods of the IGY. Information relating to the ionosphere has already been published as an instruction manual, Vol. III of the Annals (the first volume to be published), "The Ionosphere." This consists of four parts, Ionospheric Vertical Soundings, The Measurement of Ionospheric Absorption, The Measurement of Ionospheric Drifts, Miscellaneous Radio Measurements, and is edited by W. J. G. Beynon and G. M. Brown. Produced in two sections, comprising Part I and Parts II, III, and IV respectively, the complete volume was published by July 1, namely the beginning of the IGY. Future volumes will include manuscripts by A. Danjon, B. Decaux, and W. Markowitz on longitudes and latitudes; by Sidney Chapman, C. W. Gartelein, C. Hoffmeister and J. Paton, and F. E. Roach on aurora and airglow; by J. A. Simpson and H. Elliott on cosmic radiation; by J. Bartels, S. Chapman and J. H. Nelson, E. Thellier, A. Maxwell, E. Selzer, G. Grenet, A. G. Kalashnikov, L. Cagniard, and V. Froitskaja on geomagnetism; and by J. P. Rothe on seismology. Other authors whose papers are now in hand include H. S. Jones, G. F. Walton, K. R. Ramanathan and J. V. Dave, and G. M. B. Dobson. Subscription rates for each volume are £6 ($17) and it is anticipated that four to six volumes of approximately 400 pages each will be published during 1957 and 1958. Subscription orders should be placed with the publishers, Pergamon Press, 4 & 5 Fitzroy Square, London, W.1., England, or 122 E. 55th St., New York 22, N.Y.

1956 PROCEEDINGS OF ASTM. The 1956 edition of the ASTM Proceedings has recently been published. The 1,510-page volume which records the accomplishments of the American Society for Testing Materials (ASTM) for the year 1956, includes technical reports and papers with discussions. A summary of the 59th Annual Meeting held June 1956 noting the title and author of each paper presented is included. This covers 32 technical sessions. The president's annual address, given by C. H. Fellows, "The Challenge of Nuclear Energy Accepted by the Electric Power Industry and ASTM, examines the development of an economically competitive nuclear energy heat source for production of electric power. Reports of 80 technical committees with appendixes and 52 technical papers with discussions are included in the volume. Symposia published separately as Special Technical Publications and all papers published in the ASTM Bulletin during the year are listed by title and author. The 41 technical sessions and 8 industry luncheons held at the 2nd Pacific Area meeting September 1956 are also noted by author and title. The Proceedings contain reports and technical papers, many of which have been given at society national meetings. Some have been preprinted. However, most important, the Proceedings contain discussions that have not previously been published. The Proceedings is the official repository for factual information about the activities of the ASTM. Copies of this book may be obtained from the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., at $12 each.

FLAMMABLE LIQUID TRADE NAME INDEX, NFPA NO. 325A. A revised edition published by the National Fire Protection Association (NFPA) Boston, Mass. The new edition of the index lists the flash points of 3,600 flammable liquid trade name products and identifies each product as to its principal uses, manufacturer, and the NFPA's source of information about it. The first edition of the index, an 82-page informational booklet had contained data on only 2,400 products. The current index is a 120-page book. The index has been compiled by the NFPA as a guide to safe storage and use of flammable liquids; the flash point of a liquid is a good indication of its relative flammability. The index may be obtained from the NFPA Publications Department; per copy price is $1.50 with discounts for quantity purchases.

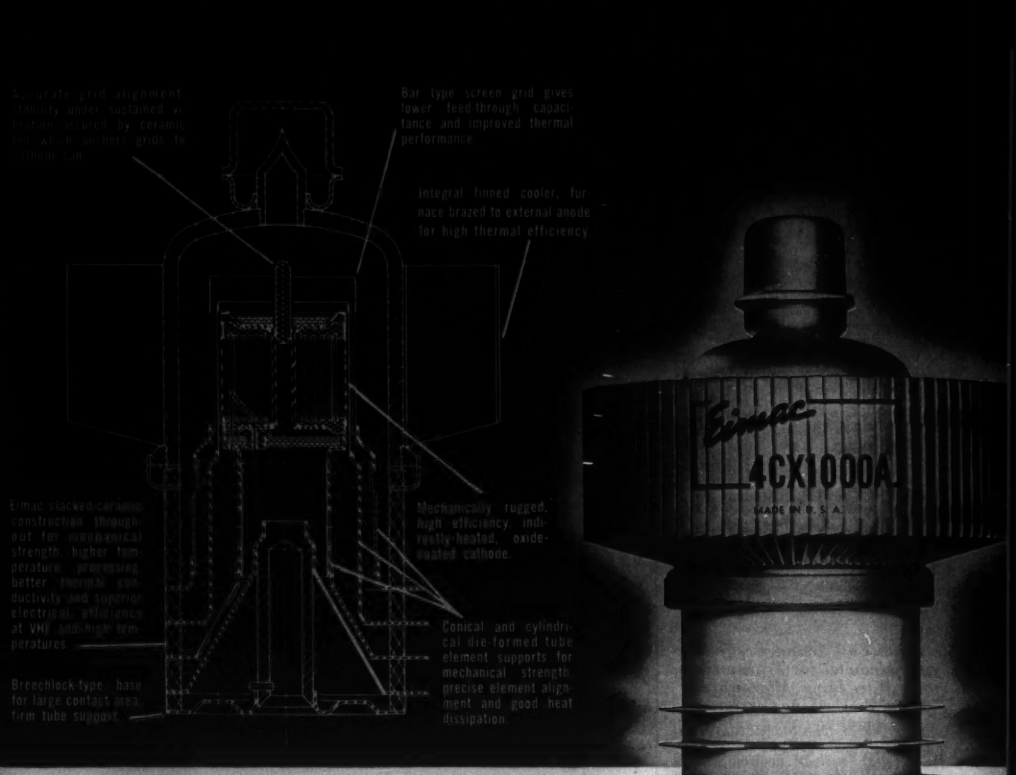
AUTOMATIC RECORD CHANGER AND TAPE RECORDER SERVICE MANUAL—VOLUME 9. Published by Howard W. Sams & Co., Inc., 2201 E. 46th St., Indianapolis, Ind., this volume presents complete service information on 14 tape recorders and 4 record changers produced in 1956. Presented on each recorder and changer are the exclusive copyrighted "Photofact Exploded Views," operational data, and detailed service instructions originated by the Howard W. Sams engineering staff. The index lists all models which were presented in the first eight volumes as well as those covered in Volume 9. Thus, reference to this index will disclose which volume in the series contains the desired information. A cross-reference index which identifies the makes and models of changers used in various radio and television receivers is also provided. This reference is intended to speed the identification of the changer type so that proper service information can be located. Containing 256 pages, Volume 9 is sold through electronic parts distributors. It carries the Howard W. Sams catalog No. *CM-9*, and sells for $3.95.

COLOR TELEVISION COURSE. This course, designed and written for men with previous radio-television training is now available from the Radio-Television Training Association (RTTA), New York, N.Y. As a complete color television correspondence course, it includes the latest, up-to-the-minute data and procedures for the servicing and maintenance of all color television receivers and equipment. The step-by-step approach found so successful in the teaching of the popular Radio-FM-television Course, FM-Television Course, and Television Studio Technician Course is again used. Starting at the transmitter, the course guides the student through the development and the transmission of the composite color television signal. With an over-all view of how the receiver functions, each circuit is then analyzed in a simple, easy-to-follow manner that makes for fast and accurate learning. A knowledge of how color television circuits work, both as individual and as co-operative units in the receiver, prepares the student for all future color television developments. A special supplementary lesson, "Survey of Color Television," an exclusive feature of the course, is printed in full color. It is the result of the co-operative efforts of RTTA and Sylvania Electric Products, Inc. Because color television has its own peculiar servicing problems, the student also receives thorough training on test instruments, alignment, and servicing. Full information and catalog may be obtained by writing Radio-Television Training Association, Dept. PR-1, 52 E. 19th St., New York 3, N.Y.

GLOSSARY OF TERMS IN NUCLEAR SCIENCE AND TECHNOLOGY. For the first time, scientists and others interested in atomic energy will have a standard "dictionary" to establish precise meanings for hundreds of technical terms used in the rapidly-growing nuclear field. The American Standards Association (ASA) and The American Society of Mechanical Engineers (ASME) announced jointly that a 188-page volume entitled "Glossary of Terms in Nuclear Science and Technology" has been approved as an American Standard, and will be published as such by ASME. Designed to provide a common language among medical men, engineers, chemists, physicists, biologists, and others working with the atom, includes three categories of terms: (1) those invented expressly for the field of nuclear energy, (2) those borrowed from other fields and employed here with different meanings, and (3) those used elsewhere, but which may be unfamiliar to nuclear workers. Definitions, tables, charts, and equations considered useful are included in the glossary. Among terms coined since the beginning of the atomic age are informal expressions which have achieved official status by inclusion in the glossary, such as "coffin" (a container for radioactive materials), "graveyard" (a place for storing burying containers of radioactive materials), and "parent" (an atom which splits to form "daughter" atoms). Approval by the ASA is the culmination of a long project begun in 1948 by 21 technical societies with interests in the nuclear energy field. ASME's comprehensive directory was used as a base; other organizations worked on specific parts, which were reviewed and revised by National Research Council's (NRC) Board of Critics; and a combined version of the nine separate sections was printed in 1955. The NRC which is the copyright owner, submitted the newest glossary for approval as an American Standard in July 1956. This version, containing additions and corrections, was published as an ASME Standard early in 1957, and served as a draft for ASA approval. That the glossary has already found wide acceptance is evidenced by the fact that preliminary drafts were requested for use at the 1955 International Geneva Conference on Peacetime Atomic Energy and the 1957 Nuclear Congress in Philadelphia, Pa. Advance copies of the American Standard were studied at the Geneva meeting of the International Organization for Standardization's Nuclear Energy Committee which met July 29-August 1. In addition, many authors and magazines have excerpted parts of the text and the British Standards Institution is using the American version as a base for its own dictionary. Copies of the glossary, designated American Standard *N1.1-1957*, may be obtained, at $5 each, by writing to The American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N.Y., or to The American Standards Association, 70 E. 45th St., New York, N.Y.

CAREER SATISFACTIONS OF PROFESSIONAL ENGINEERS IN INDUSTRY. This publication is the latest in a series of executive research reports made under the sponsorship of the Professional Engineers' Conference Board for Industry, in co-operation with the National Society of Professional Engineers (NSPE). Conducted by the Opinion Research Corporation, Princeton, N. J., the survey report is based on data gathered from interviews with several hundred professional engineers employed in industry in all the specialized technical fields. The survey questions centered around such things as the engineer outside of his work, the career outlook of engineers, satisfaction and frustration on the job, the question of professional status, and the differences in values of the more successful engineers. Copies may be obtained from the Professional Engineers' Conference Board for Industry, 2029 K St., N. W., Washington 6, D. C.; $1.50 for NSPE members, $3.00 for others.

Circle 15 on the card.


Bar type screen grid gives lower feed-through capacitance and improved thermal performance.
integral finned cooler, furnace brazed to external anode for high thermal efficiency.
Eimac stacked-ceramic construction throughout for mechanical strength, higher temperature processing, better thermal conductivity and superior electrical efficiency at VHF and high temperatures.
Mechanically rugged, high efficiency, indirectly-heated, oxide-coated cathode.
Conical and cylindrical die-formed tube element supports for mechanical strength, precise element alignment and good heat dissipation.
Breechlock-type base for large contact area, firm tube support.
Eimac
4CX1000A
MADE IN U. S. A.

New 1000 watt ceramic tetrode for SSB . . . the EIMAC 4CX1000A

Eimac fills another important transmitting need with this air-cooled, ceramic-metal, one-kilowatt tetrode . . . the 4CX1000A. Specifically designed for single side band operation the 4CX1000A is a low-voltage, high-current Class AB_1 RF or AF linear amplifier tube, exhibiting high power gain and exceptionally low distortion characteristics. The 4CX1000A achieves its maximum rated output power with zero grid drive, thus minimizing driver stage design problems and eliminating one source of distortion.

Eimac stacked ceramic design gives the 4CX1000A excellent immunity to damage by mechanical and thermal shock. Electrical stability is assured by internal ceramic support of the tube elements and clean internal design. Ideal for applications where space is at a premium, this mechanically-rugged, electrically-reliable thousand watt tetrode measures less than 5 inches high and 3½ inches in diameter. High temperature processing, made possible by Eimac ceramic-metal design, produces an extremely clean tube. This ideal environment assures long life for the efficient oxide-coated cathode.

Efficient, trouble-free socketing and cooling is provided for the 4CX1000A by the new SK-800 Air System Socket and SK-806 Chimney.

Write our Application Engineering Department for a brochure and data sheet describing this important new tube in detail.

EITEL-McCULLOUGH, INC.
SAN BRUNO · CALIFORNIA
***Eimac First* for quality, dependability and performance**

MAXIMUM RATINGS (Per Tube)

DC Plate Voltage	3000 Volts Max.	Plate Dissipation	1000 Watts Max.
DC Screen Voltage	350 Volts Max.	Screen Dissipation	12 Watts Max.
DC Plate Current	1.0 Amps Max.	Grid Dissipation	0 Watts Max.

TYPICAL OPERATION SINGLE-TONE SSB

DC Plate Voltage	2500 Volts	DC Plate Current	1.0 Amps
		Actual Plate Input	1400 W

Telemeter ANY VARIABLE from Remote Points

Accurate, Fast Acting, Frequency Type Telemeter for Transmission over Wire Lines, Microwave, and Power Line Carrier

Accurate HIGH-SPEED Continuous Telemeter for VOLTS AMPS WATTS VARS ETC.

•

Built-in Self-Calibrating Circuit

•

The Model 1025 Telemeter Transmitter converts DC mv from thermal converters, etc., to 10-30 cps which frequency modulates a built-in audio tone channel. AC 10 to 30 cps or relay outputs are also available. Receiver detects and demodulates transmitted signal, generating a DC mv for operation of recorders or indicating instruments. Up to 45 telemeters can be multiplexed.

Any communication link, including power line carrier, microwave or wire line may be used.

Over-all accuracy is 1% with a response speed of 1 second. Equipment features a built-in calibration circuit for 10% and 90% receiver check, and 10 cps and 30 cps transmitter check.

Any quantity which may be converted into a DC millivoltage or will operate a slidewire may be telemetered.

WE CAN HELP YOU
Our Applications Department is ready to assist you in your control, telemetering or communications problem. Phone DEerfield 4-2100.

Write for Technical and Application Data.

Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

INDUSTRIAL NOTES

Deflection Components Developed. Development of two new color television deflection components for operation in television receivers using the round all-glass color picture tube Type *21CYP22* has been announced by the marketing department, Radio Corporation of America, Components Division, Camden, N. J. The horizontal output and high voltage color transformer utilizes a small super-ferrite core for high efficiency. The color television deflection yoke is the first designed for mounting directly on the neck of the picture tube. The horizontal output and high voltage transformer, *RCA-XD-3207*, supplies the high voltage for the anode of the picture tube and also provides power for the yoke. The deflection yoke is the device developing a magnetic field to move the electron beam back and forth across the face of the picture tube.

Motor Starters Meet NEMA Ratings. All General Electric Size 0 and 1 magnetic contactors and motor starters in across-the-line, nonreversing, combination, and reversing forms meet the new National Electrical Manufacturers Association (NEMA) standards for motor starters. Size 0 starters are now rated up to 5-hp at 440/600 volts and Size 1 starters are rated for 10-hp at 440/600 volts. Lower cost and smaller size are two advantages that can be obtained from the reratings. A Size 1 starter can now be used on some applications that formerly required a Size 2. In many cases, a Size 0 unit can now be used instead of a Size 1. The company's new "*100* Line" Size 0 and 1 magnetic contactors and starters are built to meet the new NEMA ratings. For further information contact General Electric, Schenectady 5, N. Y.

Narda. Because of the increasing level of production test activity on its commercial and military microwave products, The Narda Corporation has set up a new and separate production test department. The new department was formerly a component of Narda's engineering laboratories which were responsible both for engineering development and production testing, the two activities employing essentially the same skills and equipment. At present, the production test department will be located at The Narda Corporation headquarters, 160 Herricks Rd., Mineola, N.Y. Plans are now being made for future transfer to new quarters.

Man-Made Moon Encased in Gold. To facilitate optical tracking and to provide protection from the elements in outer space, the Earth Satellite has been plated with Sel-Rex Bright Gold, produced by Sel-Rex Corporation, Precious Metals Division, Nutley 10, N. J. In order to evaluate properly and compute data transmitted from the satellite, it must be tracked optically and by radio during the entire journey through space. Considering also the tremendous stresses and strains and torturous atmospheric conditions to which the satellite will be subjected, it becomes apparent that some very special metallurgical properties were needed in the materials of construction. Magnesium was selected as the basic material of construction. Gold for the satellite's outer skin will provide maximum reflectivity which would, figuratively, leave tracks in space for the earth data receiving stations to follow. This patented Bright Gold electroplating formulation was selected because its deposits retain all the desirable metallurgical properties of 24K gold in addition to being twice as hard, more dense, and reflective.

Semiconductor Irradiation Research. Basic experimental and theoretical research to explain the effects of radiation damage on semiconducting materials is now in progress at Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio, under a contract with the Air Research and Development Command's Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. Advances made in the design of weapons and weapon systems have created a need for a more detailed knowledge of the properties of all kinds of materials. This is particularly true of solid-state electronic devices that may be called upon to operate at high ambient temperatures and in strong fields of radiation, such as those in the vicinity of nuclear blasts or near nuclear power plants in aircraft, guided missiles, ships, or submarines.

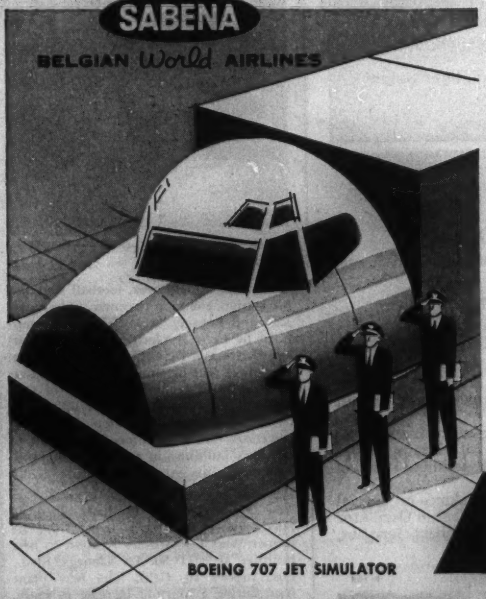
New Lapping Technique. A new technique for obtaining critical flatness and parallelism in the production of germanium, silicon, quartz, barium titanate, and lead zirconate crystals and wafers has been introduced. A lapping operation on a "Lapmaster," in combination with the new patented Lapmaster diamond fixture,

can produce a flatness under 3 light bands, a parallelism of 50 microinches and a thinness of 0.001 inch on these crystals or wafers. For full details contact Crane Packing Co., Dept. EGN, 6400 Oakton St., Morton Grove, Ill. In Canada: Crane Packing Co., Ltd., 617 Parkdale Ave., N., Hamilton, Ont., Canada.

(Continued on page 20A)

ORE of the world's leading airlines order JET SIMULATORS by Curtiss-Wright

AIR FRANCE LUFTHANSA



BOEING 707 JET SIMULATOR

Air France, Lufthansa and Sabena are the latest in the register of the world's foremost airlines which have selected Jet Simulators by Curtiss-Wright.

These leading airlines have one thing in common—years of experience in providing the ultimate in passenger service and comfort. To maintain and extend their high level of operations into the jet transport age calls for precision crew training in every aspect of jet operations. For this purpose the unanimous choice of these worldwide carriers is the electronic flight Simulator built by Curtiss-Wright.

Many of the airlines purchasing Jet Simulators have long experience with one or more of the 25 types of Flight Simulators designed and built by Curtiss-Wright. Simulators by Curtiss-Wright are in operation or on order for more commercial airlines than are those of all other manufacturers combined. Watch for other leading world airlines to select the advanced performance and fidelity of Flight Simulators by Curtiss-Wright.

ELECTRONICS DIVISION
CURTISS-WRIGHT
CORPORATION • CARLSTADT, N. J.

CURTISS-WRIGHT DEHMEL training equipment licensed under basic patents of R. C. DEHMEL AND CURTISS-WRIGHT. Canadian Licensee: Canadian Aviation Electronics Ltd., Montreal—British Licensee: Redifon Ltd., London—French Licensee: Société d'Electronique et d'Automatisme, Paris

For more information circle 17 on reader service card.

APPLICATIONS

Electrical and Acoustical Measurements
Electrical Communication Systems (Selective Calling)
Remote Operation and Supervisory Control of Machinery and Apparatus
Electrical Computers and Telemetering Systems
Electro-Mechanical Bandpass Filters

Frahm Oscillator Controls, Type ROC, make possible the design and construction of inexpensive, precision tone generators that are small and light weight. These generators will have accurate output frequency and output voltage with very nearly sinusoidal wave shape.

They can be made with any one nominal control frequency between 20 and 1100 cps. They will control the output frequency of circuits, under specified conditions, constant within ±0.15% of the nominal control frequency.

We particularly encourage your inquiries and correspondence on special applications and problems. If you haven't explored these Frahm Oscillator Controls we'll be glad to send you complete specifications, characteristics, etc. Write for Bulletin 34-EE.

B-709

JAMES G. BIDDLE CO.
ELECTRICAL TESTING INSTRUMENTS • SPEED MEASURING INSTRUMENTS
LABORATORY & SCIENTIFIC EQUIPMENT
1316 ARCH STREET, PHILADELPHIA 7, PA.

Circle 18 on the card.

Industrial Notes

(Continued from page 18A)

Power Switch Design. This huge 30-section 3-pole 6-position ceramic power switch which achieves 540 contact combinations was designed and produced by Centralab, a Division of Globe-Union Inc., 900 E. Keefe Ave., Milwaukee 1, Wis., for a West Coast aircraft manufacturer. The switch is an extended version of the popular Centralab *PA-230* heavy duty series which features square rotor shafts in monel bearings for smooth, backlash-free performance, 3,000 volts RMS and will handle a kilowatt. Versions of this switch are applicable to transmitters, industrial controls, and laboratory equipment. For further information contact the manufacturer.

General Electric. When the new U. S. Air Force Academy at Colorado Springs, Colo., opens its doors in the Fall of 1958, some 1,186 cadets will begin living better electrically with enough electric power to supply an average city of 20,000 persons. Two master unit substations to furnish this power are already installed and operating, giving power for construction of the Academy. Ultimately, they will serve

Courtesy General Electric

classrooms, airfield area, football stadium, fire station, community center, cadet quarters, and housing areas. They were supplied by General Electric's Medium Voltage Switchgear Department, Philadelphia, Pa. Power will be supplied to the substations at 34,500 volts by the City of Colorado Springs Department of Public Utilities. The stations will "step down" the power to 12,470 volts for distribution to Academy buildings in a grounded-neutral, 3-phase, 4-wire system.

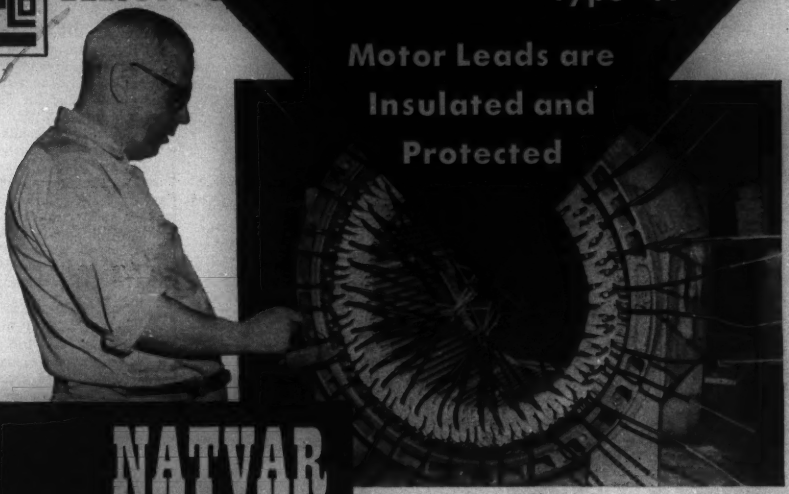
New Plant. Gertsch Products, Incorporated, has completed a move from its former West Los Angeles location to new facilities at 3211 So. La Cienega Blvd., Los Angeles 16, Calif. The new plant representing a fourfold increase in space, has been necessitated by sales and shipments which have increased by 70% over a like period last year. The company is a producer of high precision instruments and transformers for laboratory and production use.

(Continued on page 24A)

Circle 19 on the card.

ELLIOTT

Type "N"
Motor Leads are Insulated and Protected



Natvar tubing installed on coil leads and connectors of a larger a-c motor.

NATVAR VINYL COATED FIBERGLAS TUBING

Natvar vinyl coated fiberglas tubing, as applied to these a-c field coil leads, gives ample electrical protection and flexes easily.

▼ Line-up of NEMA frame motors with Natvar tubing applied to coil leads.

The Crocker-Wheeler plant of Elliott Company builds a wide variety of electrical motors in sizes up to 200 hp. Natvar vinyl coated tubing is widely used on Crocker-Wheeler a-c induction motors in both large and small ratings.

Factors which make Natvar tubing especially suitable for the protection of motor coil leads and connectors are its uniformly high dielectric value, mechanical strength, resilience, and resistance to cold flow. It is used in both Class A and Class B insulated machines.

If you need insulating materials with good physical and electrical properties and exceptional uniformity, it will pay you to get in touch with your distributor or with us direct.

Natvar

Natvar Products

- Varnished cambric—cloth and tape
- Varnished canvas and duck
- Varnished silk and special rayon
- Varnished—Silicone coated Fiberglas
- Varnished papers—rope and kraft
- Slot cell combinations, Abeglas®
- Iseglas® sheet, tape, tubing and sleeving
- Vinyl coated—varnished—lacquered tubing and sleeving
- Extruded vinyl tubing and tape
- Styroflex® flexible polystyrene tape
- Extruded identification markers

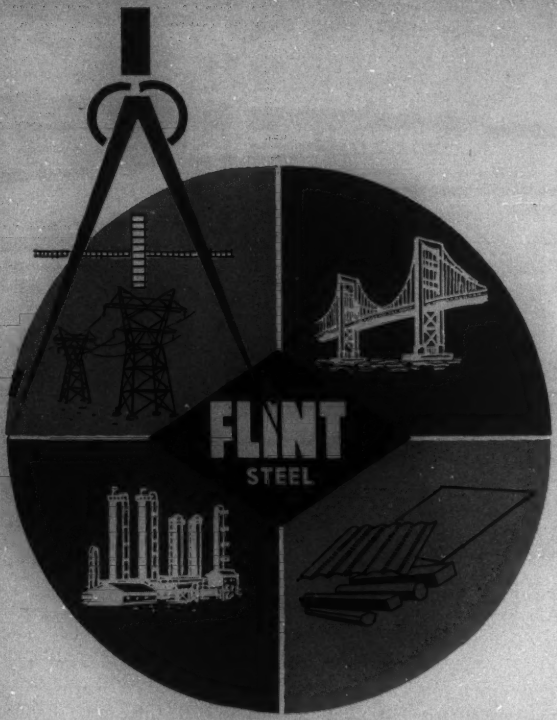
Ask for Catalog No. 23

NATVAR CORPORATION

FORMERLY THE NATIONAL VARNISHED PRODUCTS CORPORATION

TELEPHONE FULTON 8-8800 — CABLE ADDRESS NATVAR: RAHWAY, N. J.

203 RANDOLPH AVENUE • WOODBRIDGE, NEW JERSEY



There is a distinct advantage in "divided responsibility" when this "responsibility" represents specialists in their own field of endeavor.

At Flint, four distinct divisions,

FABRICATED PLATE

TOWER and SUBSTATION

STRUCTURAL and REINFORCING

STEEL WAREHOUSE

are inter-related and singly managed.

Some clients take advantage of all *four*, others one or more.

Flint invites you to investigate the possibility of using these facilities to your advantage.

for over 40 years

FLINT STEEL CORPORATION

TULSA . . . MEMPHIS

Circle 22 on the card.

Industrial Notes

(Continued from page 20A)

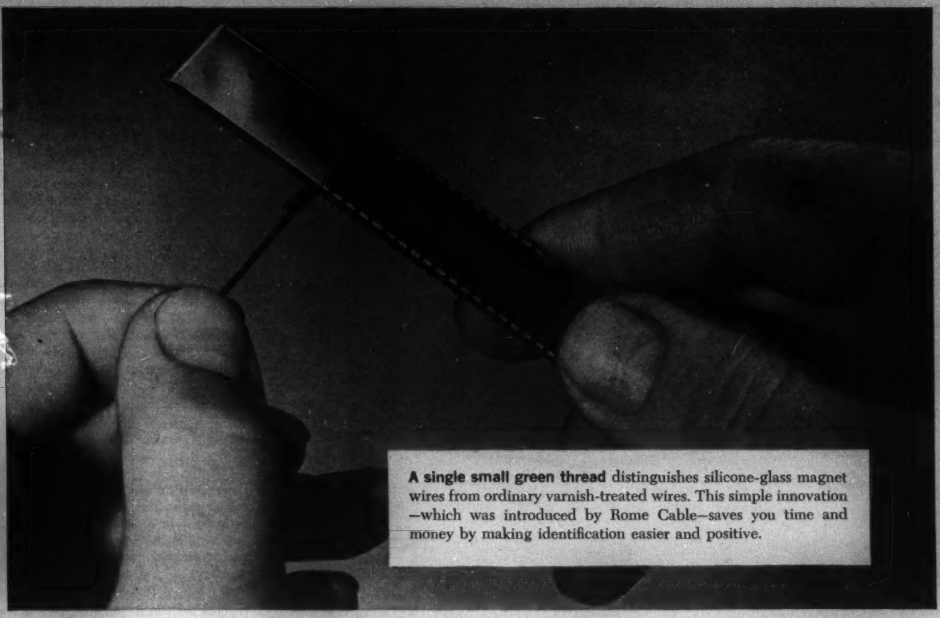
Burroughs Relocation. Burroughs Corporation, prime contractor for electronic data processing and transmitting equipment for the SAGE system of continental air defense, and for guidance computers used in the U.S. Air Force's intercontinental ballistics missile program, has relocated and expanded its Los Angeles, Calif., and Dayton, Ohio, defense district offices. The Dayton office, formerly located at 392 W. First St., has moved to larger quarters at Suite 202, 3898 Linden Ave., while the Los Angeles office, formerly located at 1647 Wilshire Blvd., has been relocated in larger quarters at 17071 Ventura, Encino, Calif.

Viewer for Long Prints. A convenient, space-saving long-print holder, called ROLL-O-PRINT for viewing blueprints, drawings, photos, maps, etc., up to 40 feet or more in length in an area of approximately 40 inches by 48 inches on wall, table, desk, or station wagon tailgate, is now available for manufacturers, engineers, builders, surveyors, planners, foremen, estimators, blueprint checkers, assemblers, draftsmen, shipbuilders, and aircraft workers. For literature and complete details, including free 15-day trial offer plan, write to: Aqua Sportsman, Inc., Dept. 130, 2518 Leslie Ave., Cincinnati 12, Ohio.

Continuous Belt Conveyor Oven. A unique type of oven, much in demand for automation, has been developed by the Grieve-Hendry Co., Inc., recently. A conveyor belt carries the product through the heated zone and can be arranged for both automatic loading and unloading facilities. These ovens are used for drying and baking processes, dehydrating, and baking on finishes. The oven is equipped with counter-balanced doors at each end, adjustable for opening desired. These ovens can be made for heating by gas, electric, or steam. Dimensions and other specifications can be changed to suit requirements. Full information may be had by writing the manufacturer, Grieve-Hendry Co., Inc., 1401 W. Carroll Ave., Chicago 7, Ill.

IBM. An automatic assembly machine which takes orders from itself has been announced by International Business Machines Corporation, 590 Madison Ave., New York 22, N.Y. The device is used to fasten resistors, capacitors, diodes, etc., automatically, onto printed circuit panels before they are inserted into computers and other electronic equipment. The new machine goes a big step further. When a change in the layout and components of a panel is in order, gone is the old manual resetting job. Instead, the machine gets instructions from IBM cards and then automatically resets itself for the new assignment. The new device is called the Programmed Component Assembly System.

(Continued on page 32A)



A single small green thread distinguishes silicone-glass magnet wires from ordinary varnish-treated wires. This simple innovation—which was introduced by Rome Cable—saves you time and money by making identification easier and positive.

Insulated by a tough silicone-glass covering . . .

Rome's "green thread magnet wire" permits easier-wound coils for Class H equipment

You can prove to yourself that Rome Cable's silicone-glass magnet wire is best by comparing its properties with those of any other. It will pass *any* reasonable test you can give it. This premium quality magnet wire features:

High heat resistance—ideal for Class H equipment (180° C. hottest spot).

Outstanding abrasion resistance—this wire is made to order for the tight tension blocks and severe handling involved in coil winding.

High tensile strength—this tough insulation won't crack under the tension of coil winding.

Perfectly bonded—this skip-free covering is tightly bonded to withstand severe bending.

In addition to the toughness and heat resistance of its insulation, this magnet wire features a copper conductor with consistently accurate dimensions, a surface free of burrs and defects, and the correct copper softness—all the result of Rome Cable's step-by-step quality control.

And—since proper spooling of finished wire is of real importance—Rome Cable accurately winds *each* layer. Spools are then carefully packed to prevent any damage during shipment.

Many magnet wire users are now specifying Rome's green thread wire for Class H use because they know that this silicone-glass magnet wire is more dependable and easier to use than any other. Why don't you do the same?

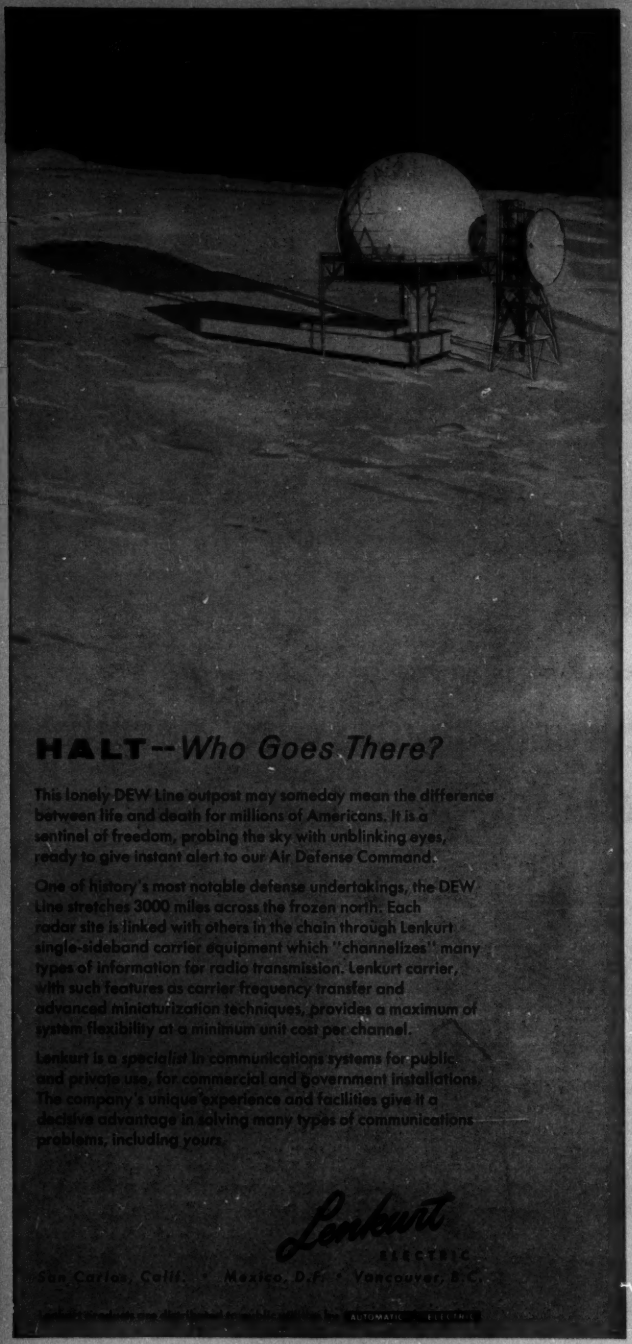
Contact your nearest Rome Cable representative for more information—or write to Department 203, Rome Cable Corporation, Rome, New York.

High tensile strength of insulation is a *must* when winding transformer coils. Rome's silicone-glass magnet wire readily meets this requirement.

ROME CABLE

CORPORATION

For more information circle 28 on reader service card.


HALT--Who Goes There?
This lonely DEW Line outpost may someday mean the difference between life and death for millions of Americans. It is a sentinel of freedom, probing the sky with unblinking eyes, ready to give instant alert to our Air Defense Command.
One of history's most notable defense undertakings, the DEW Line stretches 3000 miles across the frozen north. Each radar site is linked with others in the chain through Lenkurt single-sideband carrier equipment which "channelizes" many types of information for radio transmission. Lenkurt carrier, with such features as carrier frequency transfer and advanced miniaturization techniques, provides a maximum of system flexibility at a minimum unit cost per channel.
Lenkurt is a specialist in communications systems for public and private use, for commercial and government installations. The company's unique experience and facilities give it a decisive advantage in solving many types of communications problems, including yours.
Lenkurt
ELECTRIC
San Carlos, Calif. • Mexico, D.F. • Vancouver, B.C.
Circle 29 on the card.

Industrial Notes

(Continued from page 24A)

2,000-Watt Converter. What is to be the largest d-c to a-c converter made by Carter Motor Company is now in process of development. Advance information can be had by addressing Ray Simon, Chief Engineer, Carter Motor Co., 2711A W. George St., Chicago 18, Ill. Over-all size is 11 inches by 19 inches by 12 inches high. Input voltage models will be available for 32, 48, 64, 115, and 230 volts d-c with a-c outputs of 115 volt or 230 volt, 50 or 60 cycle, single or 3-phase. Output capacities of 1,500 watt or 1,250 watt also will be offered, in addition to the 2,000 watt model. Most significant engineering feature is the use of 4-pole design to reduce armature operating speed to 1,800 rpm with consequent longer life and quiet operation.

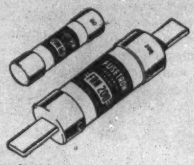
Company Name Change. The Narda Corporation, 160 Herricks Rd., Mineola, N. Y., has changed its name to The Narda Microwave Corporation. The new name was chosen to reflect better Narda's greatly increased activities in the microwave and uhf test equipment field, such as the recent acquisition of Kama Instrument Corporation, and a general expansion of the company's research and production facilities.

Reactor for Denmark. The first atomic energy reactor for Denmark has begun operating near Copenhagen. Atomics International, a Division of North American Aviation, Inc., P. O. Box 309, Canoga Park, Calif., is the designer and builder of the research reactor for the Danish Atomic Energy Commisson. The reactor, located at the new Danish AEC nuclear research center about 20 miles west of Copenhagen, will be used for nuclear engineering and training, radioisotope production, and for research in the fields of physics, medicine, chemistry, and agriculture.

Interference Measurement Service. Enlargement of its North Adams, Mass., radio interference measurement facilities has been completed by the Sprague Electric Company, which now offers a custom interference measurement service on all types of electric machinery such as dynamotors, actuator motors, vibrator power supplies, etc., as well as on electronic equipment. This is the third such laboratory set up by Sprague; the other two have, for the past few years, been in operation in Los Angeles, Calif., and Dayton, Ohio. In addition, an expanded interference filter sample shop and pilot plant have been inaugurated to expedite service to customers with interference problems. This service has proved helpful to missile, electronic equipment, and portable tool manufacturers, both on the East and West coasts. Interference engineering services also are available to customers for consultation and work at their own facilities in those cases where it is impractical to bring the equipment to one of these three laboratories.

If you want fuses that — abolish all needless blows, stop overheating in panels and switches, protect motors against burnouts . . .

Use FUSETRON dual-element Fuses



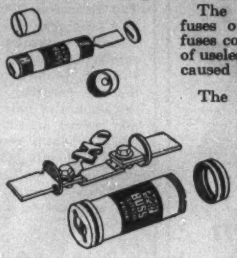
With rare exceptions, ordinary fuses or circuit breakers do not protect except against short-circuit but FUSETRON fuses provide TEN POINT protection.

1. Protect against short-circuits.
2. Protect against needless blows caused by harmless overloads.
3. Protect against needless blows caused by excessive heating — lesser resistance results in much cooler operation.
4. Provide thermal protection — for panels and switches against damage from heating due to poor contact.
5. Protect motors against burnout from overloading.
6. Protect motors against burnout due to single phasing.
7. Give DOUBLE burnout protection to large motors — without extra cost.
8. Make protection of small motors simple and inexpensive.
9. Protect against waste of space and money — permit use of proper size switches and panels.
10. Protect coils, transformers and solenoids against burnout.

FUSETRON duel-element FUSES save you time and money because they are made to PROTECT — not to blow.

If you want Renewable Fuses . . .

Use BUSS Super-Lag Renewable Fuses



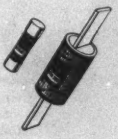
The big advantage of these fuses over all other renewable fuses comes from the prevention of useless interruptions of service caused by needless blows.

The reason for this performance is found in the design of the fuse-case which assures good contact on the fuse link, even if the fuse is renewed by an inexperienced person — and by the time-lag built into the link that prevents the fuse from opening on motor starting currents or other harmless overloads.

If you want SAFE protection on loads above 600 and up to 5000 amps . . .

Use BUSS Hi-Cap Fuses

On voltages up to 600, high speed operation on heavy shorts limits current to safe values. This minimizes damage to equipment and cuts down dangerous stresses on transformers.



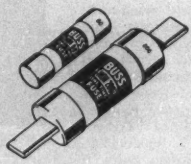
For Short-Circuit Protection or when fast opening is desired . . .

Use BUSS Limitron Fuses

The extremely fast opening characteristics of these fuses prevent heavy short-circuit currents from building up under fault conditions.

If you want Non-Renewable Fuses . . .

Use BUSS One-Time Fuses

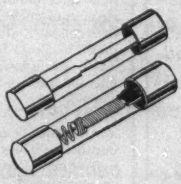


They save you time and trouble because they get the same engineering care in manufacture as do all products carrying the BUSS Trademark.

Every BUSS One-Time fuse can be depended upon to operate as intended under all service conditions.

For protection of TV, Radio, Instruments, Radar, Avionics and Electronic Equipment . . .

Use BUSS and FUSETRON Small Dimension Fuses



A complete line is available. Made in Dual-element (slow-blowing), Renewable and One-Time types in sizes from 1/500 ampere up.

And there is a companion line of BUSS Fuse Clips, Fuse Blocks and Fuse Holders to take them.

circuits they are protecting and therefore no occasion to open.

Yet, after years of inactivity, you can be sure the fuse will give the same safe, dependable protection if called upon to open as it would have on the day it was installed.

NO RECALIBRATION COSTS

When Fusetron fuses do blow, there is no recalibration needed. As quickly as the fault in the circuit is corrected, you slip in a new fuse that has been CALIBRATED AT THE FACTORY BY ENGINEERS — a fuse that is as safe and dependable as the one that blew.

FOR MORE INFORMATION ON BUSS AND FUSETRON FUSES WRITE TO BUSSMANN MFG. DIVISION McGRAW-EDISON CO. ST. LOUIS 7, MO.

FUSETRON

TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION

BUSS

1137

Fusetron Fuses Now! THROUGHOUT THE ENTIRE ELECTRICAL SYSTEM

now!

Custom Conversion of

Teflon° - Kel-F†

To Your Order!

Experimentation •
Design •
Fabrication •

To Your Specifications!

• Any Shape
• Any Size
• Any Quantity

Fluorulon Laboratories at Caldwell, N. J. was created for the specific purpose of producing customized products of Teflon° and Kel-F† plus all standard forms . . .

Extruded Molded
Filled Coatings

Color and Glass Impregnation

FLUORULON Laboratories
Box 305 Caldwell, N. J.
Phone: CAldwell 6-8228

†Kel-F is the registered trade name of the M. W. Kellogg Company.

°Teflon is the registered trade name of E. I. du Pont de Nemours & Co.

Circle 32 on the card.

NEW PRODUCTS

Tap Extension. Tapping a remote blind hole on a gear train housing for a radar assembly is accomplished with ease and accuracy by means of a tap extension. Utilizing problem-solving tools, such as the tap extension, considerably reduces the amount of time and labor needed for jobs where hard-to-get-at tapping spots can slow down production and increase production costs. Manufactured by Ritmar Corporation, the extensions are available in standard lengths of 9 inches or, for special applications, the manufacturer will

Courtesy Industrial A & A Inc.

furnish them, on order, in extra lengths up to 36 inches, and with special shanks, adaptable to individual tapping equipment. A tap extension set, containing 9 different sizes of extensions to accommodate 15 different sizes of standard taps is also available. For further information and literature on the tap extensions and other problem-solving tools, write Ritmar Corporation, 183 New York Ave., Huntington, L. I., N. Y. *Circle 200 on the card.*

Transistorized Microphone. A hand-held microphone for mobile communications equipment, which features a built-in transistor amplifier, has been introduced by Shure Brothers, Inc., 222 Hartrey Ave., Evanston, Ill., manufacturer of microphones and electronic components. Named the "Transistorized Ranger," Model *505T* is a controlled magnetic microphone designed as a replacement-improvement for older carbon units. It was stated that major advantages are greater speech intelligibility and longer life. *Circle 201 on the card.*

SlaveScope. The SlaveScope may be used with any standard low-frequency oscilloscope for applications such as group viewing, production line testing, or computer read-outs. Signals from the deflection plates of the driving oscilloscope are fed through a cathode-follower adapter to the SlaveScope. The oscilloscope pattern is accurately reproduced on the large screen of the SlaveScope. The SlaveScope is supplied with a 10-foot connecting cable, but may be used for remote viewing up to 100 feet from the driving oscilloscope. For further information contact Technical Sales Department, Allen B. DuMont Laboratories, Inc., Clifton, N. J. *Circle 202 on the card.*

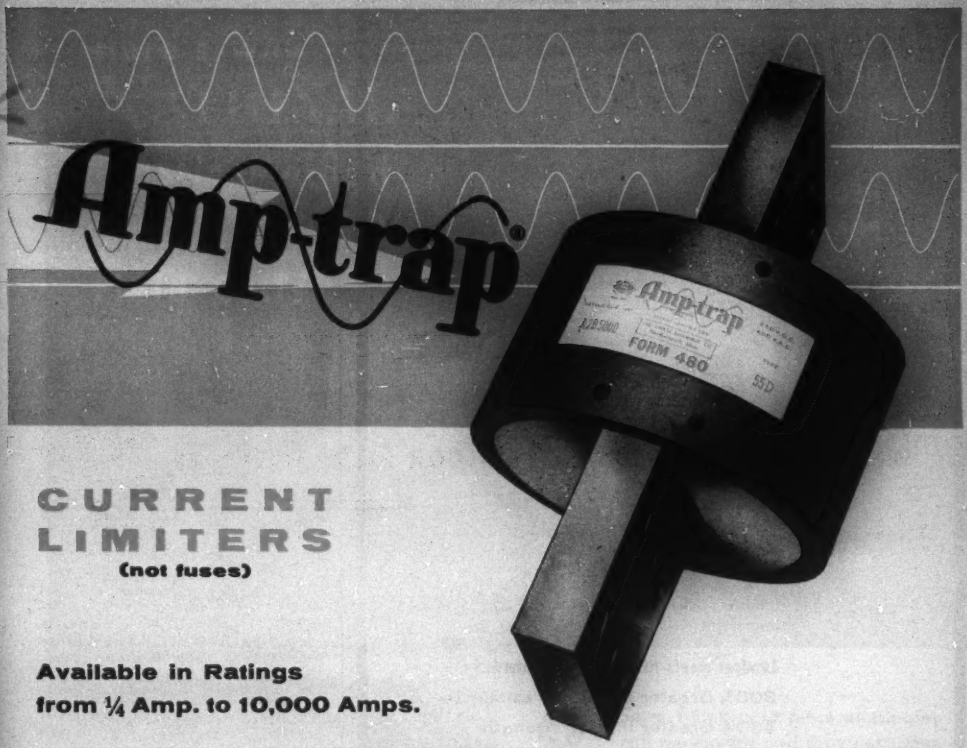
Magnetic Tape Recorder/Reproducer. A 14-channel magnetic tape recorder–reproducer system, designed to handle analog, pulse duration modulation (PDM), and FM signals, has been announced by Consolidated Electrodynamics Corporation, 300 No. Sierra Madre Villa, Pasadena, Calif. The system is extremely versatile and is expected to find wide use in wind tunnel, engine test stand, and other research studies where high-speed acquisition of large amounts of precise data is required. The unit receives information directly from sources such as RDB telemeter receivers and PDM equipment. It will also accept signals from self-generating transducers, strain gauges, bridge-type transducers, etc., when transmitted through amplification equipment. Frequency range is from 0 cycles to 100 kc at input levels from 0.25 volts rms to 25 volts rms. For additional information contact the company. *Circle 203 on the card.*

Glide-Action Lighting Unit. A lighting unit that glides and rotates readily into any one of a thousand different working positions is the recent development of Amplex Corporation. Appropriately named the "Trombolite," the new unit features, in addition to its unique light-positioning methods, a combination of

incandescent–fluorescent lighting said to provide highly improved vision-aid illumination over working areas. For further information, contact Douglas Hill, Advertising Sales Promotion Manager, Amplex Corporation, 111 Water St., Brooklyn 1, N.Y. *Circle 204 on the card.*

Current-Regulated Power Supply. The development and production of a current-regulated power supply has been announced. This supply will maintain the output current at a set value regardless of a change in the resistance of the load. The current regulated supply is especially useful for exciting focus coils and electromagnets or any application where it is de-

(Continued on page 40A)



CURRENT LIMITERS
(not fuses)

Available in Ratings from ¼ Amp. to 10,000 Amps.

FOR POSITIVE **PROVEN** PROTECTION ON **ALL** GENERAL POWER AND ELECTRONIC CIRCUITS

- **The ORIGINAL Current Limiter with ratings up to 5000 Amperes.**
- **The ONLY complete line of Current Limiters.**
- **The ONLY Current Limiter that has been proved both in the laboratory and on-the-job again and again.**
- **The ONLY Current Limiter that can interrupt 200,000 Amperes symmetrical over the entire Ampere Range.**

The Amp-trap is a true Current Limiter because it *stops* dangerous short circuit currents before they become destructive. Fuses can not do this on high power circuits.

AMP-TRAPS — *"Awake At The Switch"*

THE CHASE-SHAWMUT CO.

273 MERRIMAC STREET • NEWBURYPORT, MASSACHUSETTS

Est. 1893

© 1957 The Chase-Shawmut Co.

Subsidiary of I-T-E CIRCUIT BREAKER CO., Philadelphia, Pennsylvania

IMPROVE PRODUCT

REDUCE COMPONENT COST

INCREASE PROFIT

+

−

$

WITH ELECTRICAL GRADE LAMICOR

Class B performance at Class A cost

Lamicor, fiber glass reinforced polyester resin laminates now makes available a superior insulating material at considerable savings. Compared to all phenolic grades, LAMICOR offers the following advantages for product improvement:

Lamicor meets NEMA GPO-1 standards

300% Greater moisture resistance

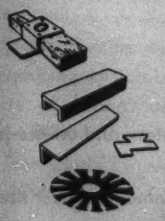
430% Greater impact strength

24% Greater flexural strength

350% Greater heat resistance

2400% Greater arc resistance

50% Cost Savings are not unusual



A complete source of supply for Lamicor sheets, channels, angles and fabricated parts.

Write today for free samples, technical information and a solution to your particular problem.

STRICK PLASTICS

PERKASIE, PENNA.

Basic Material Producers of Plastics and Laminates

Custom Vacuum Forming—Specialists on Extra Large Forms

Product Engineering and Development in Plastics and Laminates

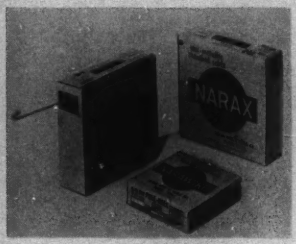
Composite Structures and Honeycomb Panels

New Products

(Continued from page 36A)

sirable to maintain a constant current. For further information contact Jobbins Electronics, 771 Hamilton Ave., Menlo Park, Calif. *Circle 205 on the card.*

Packaging Makes the Difference. PULL-REEL, a new concept in wire packaging has been introduced by the wire manufacturer, Texas Wire & Cable Company. This packaging saves costly hours of wiring time in new construction and on re-



wiring jobs; it saves wire too. Pull-Reel packages may be lined up for pulling several wires at one time. For full information and an illustrated brochure, write to Texas Wire & Cable Company, Plano, Tex. *Circle 206 on the card.*

Tube for Airborne Use. A CHARACTRON (*Stromberg-Carlson trademark*) shaped beam tube has been developed which is small enough for aircraft use, and yet able to reproduce a conventional radar display map and then print labels on it. The shaped beam tube accomplishes the dual function of a radar tube and a tube displaying characters by means of time sharing, the characters are printed on the phosphor screen at the rate of 20,000 a second and retained by the phosphor while the electronic device does its radar work in-between letters and numbers. The new model is much shorter than other models of the CHARACTRON shaped beam tube. Its compactness makes it feasible for use aboard aircraft. For further information write Stromberg-Carlson, Division of General Dynamics Corporation, Public Relations Department, Rochester 3, N. Y. *Circle 207 on the card.*

In-Line Display with Colored Digits. A model In-Line Display with digits of varying size and shape, as well as different colors has been announced. The introduction of colored digits improves the quality of presentation, provides easier reading, relieves eyestrain, and makes the In-Line Display better suited to environmental ambient room light. Digit colors available, at the user's choice, are red, green, yellow, blue, and purple. The style and shape of the digits on this latest In-Line Display

(Continued on page 42A)

Here's why

NATIONAL

Plastic Molded

COPPER-CLAD

Field Coils

Insure Longer Service Life

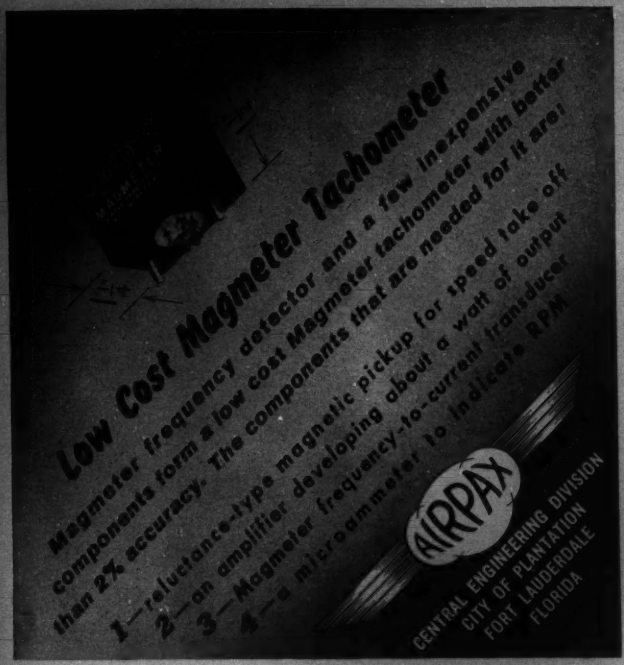
The main illustration shows a plastic molded, copper-clad interpole field coil for a railway traction motor. The small photo shows a set of such coils assembled with main field coils of the same construction in a traction motor frame. For details on how National plastic molded, copper-clad field coils can help reduce your motor maintenance problems, just drop us a line or call your nearby National field engineer.

1. **Snug fit on pole piece eliminates coil movement and provides maximum heat transfer to the frame.**
2. **Monolithic construction resists damage from mechanical stresses and insures maximum heat dissipation.**
3. **Void-free insulation prevents penetration of oil, moisture and other deteriorating agents.**
4. **Proven heat-resistant impregnant imparts high temperature endurance.**

NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A.

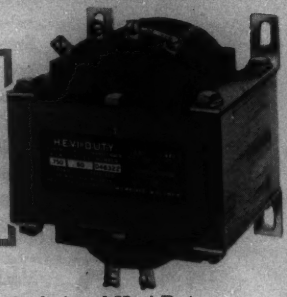
ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—
REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES


Low Cost Magmeter Tachometer
Magmeter frequency detector and a few inexpensive components form a low cost Magmeter tachometer with better than 2% accuracy. The components that are needed for it are:
1—reluctance-type magnetic pickup for speed take off
2—an amplifier developing about a watt of output
3—Magmeter frequency-to-current transducer
4—a microammeter to indicate RPM.
AIRPAX
CENTRAL ENGINEERING DIVISION
CITY OF PLANTATION
FORT LAUDERDALE
FLORIDA

▲ Circle 37 on the card.

▼ Circle 38 on the card.

you'll have
SPACE to SPARE
on your panel



. . . when you mount the newly designed Hevi-Duty Type SZO Control Circuit Transformer. Savings in panel space range up to 20 percent over units of equivalent rating. Better yet, you'll have extra inrush capacity (up to 150% more) due to Hevi-Duty's interleaved windings and other new improved proportions of design. New Type SZO transformers range from .050 to 5 KVA.

Write for Bulletin 300 for further details

HEVI-DUTY ELECTRIC COMPANY
HEAT TREATING FURNACES HEVI-DUTY ELECTRIC EXCLUSIVELY
DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS
MILWAUKEE 1, WISCONSIN

New Products

(Continued from page 40A)

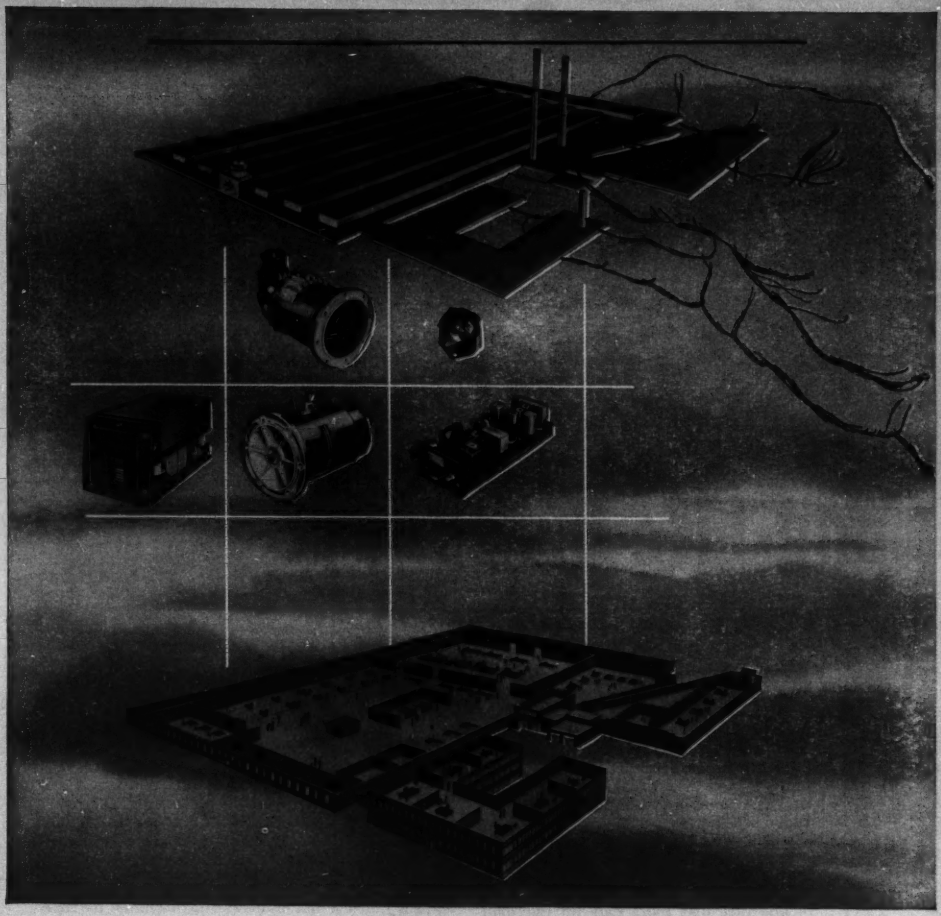
may also be selected by the user. For more complete information about this In-Line Display, write direct to the manufacturers, Industrial Electronic Engineers, 3973 Lankershim Blvd., North Hollywood, Calif. *Circle 208 on the card.*

Toolmaker's Projector. A toolmaker's projector, announced by Stocker & Yale, Inc., Green St., Marblehead, Mass., has been developed to meet the increasing needs for economical engineering, production, or tool room measuring operations. The new instrument, featuring extreme versatility and extended capacity is portable and ruggedly built for accuracy and stability under shop conditions. Ideal uses for the new Toolmaker's Projector include: circular form and single point tools; drill, tap, reamer inspections; screw machine parts; gap setting and other micro adjustments, silicon and germanium wafer inspection; gear tooth forms, thread forms, stamped, formed, machined parts, etc. Write to the company for further information. *Circle 209 on the card.*

E-Form Preformed Epoxy Pellets. These pellets are ideal for the encapsulation of electronic components and are available from Epoxy Products, Inc. The E-Form pellet is a stable, dry blend of epoxy resin and hardener, combined by means of a special technique into the shape of an easily handled preform. The size and shape of the pellet can be varied to serve as a metered charge. E-Form pellets eliminate the mixing of liquid resin and hardener with the resultant waste of labor and material; they are nontoxic, thus eliminating dermatitis. E-Cases plus E-Form pellets make mass production and automation techniques feasible inasmuch as these combinations can be automatically fed, positioned, and assembled with the use of standard available machinery. E-Cases and E-Forms eliminate the use of Dixie cup and liquid metering machines. There is no need for a trained chemist to supervise this operation. For further information on the new Epoxy E-Forms, write to Epoxy Products, Inc., 137 Coit St., Irvington, N. J. *Circle 210 on the card.*

Ratiometer. The addition of a new product, the Unity Ratiometer is announced by Servonics, Inc., 834 No. Henry St., Alexandria, Va. Among its many outstanding features the four most noteworthy include: fast accurate readout, continuous balance, automatic polarity indicator, and the fact that it is completely self-contained. There are two models of the Ratiometer, the *UV-100* and the *RV-1*. The *UV-100* has an accuracy of 0.05% full scale with an input resistance of 10. megohms. The unit is chopper stabilized. The power requirements for this model are 115 volts ±10%, 60 cps at 40 watts, with a reference voltage of ±100 volts at 2 mils. This model is adjustable to function with reference as low as ±1 volt. The

(Continued on page 46A)



Your project is halfway home before you start ...under this roof

Your aircraft or missile project may take advantage of proved hardware designs already on our shelves, saving you months of time. Actuators, control systems, any or all components for complete primary power systems . . . we have more than 100 advanced-state-of-the-art, proved designs which, with slight modification, may fit your project.

Under one roof, Jack & Heintz designers, development engineers and production people quickly accelerate a project from design to top-speed output. Such close design-production coordination encourages design flexibility, shortens lead time, speeds delivery.

This is why under our one roof we can produce the widest range of precise quality aircraft electric equipment available from any single source . . . why we may have proved designs already suited to your project.

We invite your inquiry. Write Jack & Heintz, Inc., 17622 Broadway, Cleveland 1

JACK & HEINTZ AIRCRAFT SYSTEMS AND EQUIPMENT

Now!
Long-Life Brushes
FOR FUEL PUMP MOTORS
Meet the first truly long-life brushes for 12-volt fuel pumps!
Typical of Stackpole brushes designed for specific operating conditions, these new units combine excellent commutation with long life in gas fume-laden atmospheres or immersed in gasoline, which prohibit proper commutator filming by conventional brushes.
Stackpole's chief stock in trade is its ability—based on half a century's experience—to match brush grades to on-the-job operating conditions.
The fact that more cars on the road today use Stackpole ignition system brushes than any other make offers additional evidence along these lines.
STACKPOLE CARBON COMPANY
St. Marys, Pa.
STACKPOLE
50 Years of Carbon-Graphite-Metal Powder Progress
Other Stackpole products include: Electrical CONTACTS • CERAMAGNET® Ceramic MAGNETS • VOLTAGE REGULATOR DISCS • SEAL RINGS • PUMP VANES • FRICTION SEGMENTS • CARBON BEARINGS • MOLDS and DIES • WELDING and BRAZING CARBONS • FIXED and VARIABLE RESISTORS

New Products

(Continued from page 42A)

RV-1, with an accuracy of 0.1%, has a self-contained reference of 0.01 volt (10 millivolt) full scale. This model has an input resistance of 2 megohms, which is infinite at null. Its power requirements are 115 volts ±10%, 60 cps at 45 watts. *Circle 211 on the card.*

Rubber-to-Metal Adhesive. An adhesive for bonding cured natural or synthetic rubber to metal provides a bond so strong that the rubber will tear before it can be peeled from the metal. The new adhesive is designated as *Ray-*BOND *R-86001*. Cured in 24 hours at room temperature (77 F minimum), *Ray-*BOND *R86001* reaches maximum strength after seven days. To reach maximum strength immediately, it may be cured in four hours at 120 to 140F which can be obtained from steamheated ceiling heaters, or from hot air heaters or infrared lamps in an enclosed space. Detailed information will be sent free upon request to the Adhesives Department, Raybestos-Manhattan, Inc., 940 Rayman St., Bridgeport 2, Conn. *Circle 212 on the card.*

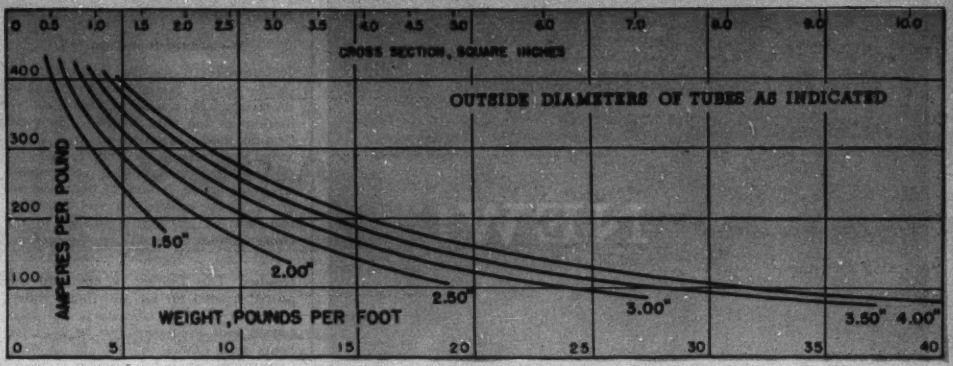
Infrared Telescope. Officially known as a Sniperscope *M-2*, this ingenious instrument has numerous applications in research and experimentation. It is also used for industrial plant security, microscope studies under infrared and ultraviolet light, spectroscopy, infrared photography, and location of fires in smoke-screened fires. With this instrument you can see in the dark without being observed. Write Edmund Scientific Co., 101 E. Gloucester Pk., Barrington, N. J. *Circle 213 on the card.*

Ultrathin Phosphor Bronze Strip. To meet the increased demands for a thinner, stronger, and absolutely uniform spring material for miniaturization applications, in the electronic, electrical, automation, and instrumentation industries the American Silver Company, 36-07 Prince St., Flushing 54, N.Y., is now precision-rolling phosphor bronze to thicknesses as low as 0.0005 inch, with thickness tolerances as close as plus-or-minus 0.0001 inch. A relatively inexpensive material, phosphor bronze exhibits high strength, long fatigue life, good electric conductivity, and excellent resistance to corrosion, as well as excellent spring characteristics. *Circle 214 on the card.*

Meter Overhaul with Ultrasonics. Ultrasonic cleaning has made it possible to salvage many types of meters and similar devices, even those which formerly had to be scrapped. The Sonogen (*registered trademark*) ultrasonic generator used for this application is a model *AP-25-B*, together with a type *T-52* tank-transducer combination, both built by Branson Ultrasonic Corporation, 40 Brown House Rd., Stamford, Conn. The generator converts

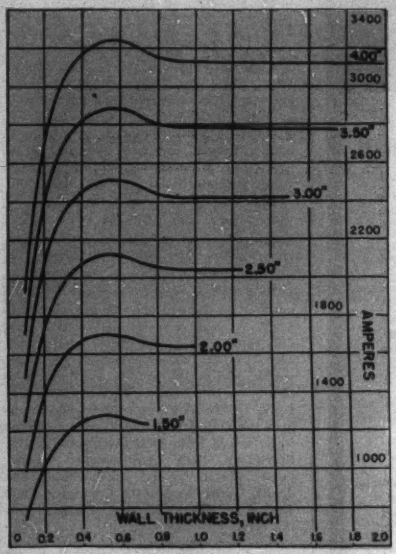
(Continued on page 48A)

Circle 42 on the card.



60-CYCLE CURRENT ratings of six round copper tubes in terms of weight per foot.

How to carry more amperes per pound of copper



THE INFLUENCE of wall thickness on the 60-cycle current rating of six round copper tubes.

THIN-WALL TUBES with low wall-thickness-to-diameter ratio offer decided electrical advantages—and opportunities for cutting bus costs—wherever mechanical requirements permit. The charts above and at the left show the 60-cycle skin-effect phenomenon characteristic of six representative sizes of round copper tube, 1.5" to 4.0" O.D. The curves cover the entire range of wall thickness from solid round rods, at the right, to the thin-walled tubes in common use at the left. What is true of round tubes is also true of other tubular bus shapes.

INSTALLATION ECONOMIES. When round tubular bus conductors can be selected in thin-wall sizes from the standard pipe dimension schedules, it is possible to effect further economies by the use of stock sizes of supports, connectors, tap clamps, and other necessary hardware available in great variety in dealers' stocks.

More complete information on tubular conductors is available in the Sixth Edition of The American Brass Company's Publication C-25. This 62-page booklet has a wealth of general information on the properties of copper conductors—plus convenient data for the most commonly used sizes of all types of rigid bus conductors.

TECHNICAL SERVICES. Anaconda specialists are available to help you in the solution of technical problems involving the use of Anaconda Bus Conductors. For such service, or for a copy of Publication C-25, see your nearby Anaconda representative. Or write: The American Brass Company, Waterbury 20, Conn. 57100

ANACONDA®
COPPER CONDUCTORS
Made by The American Brass Company

THERE'S AN ANACONDA ELECTRICAL CONDUCTOR FOR EVERY NEED

For more information circle 43 on reader service card.

P&B PROGRESS /
UNIQUE DESIGN IMPROVES WEIGHT-SIZE-PERFORMANCE FACTORS

NEW!

MINIATURE TELEPHONE TYPE RELAY HAS SUPERIOR SHOCK/VIBRATION RESISTANCE

Unusual for a telephone type relay, the MG Series has excellent stability under high shock and vibration conditions. Tests show this miniature, light weight (only 1.2 oz., open) relay withstands vibration of 10g 55 to 500 cycles per second and will operate under shock to 30g according to Mil-R-5757C.

The superior performance of the MG is due in part to its unique single stack construction and to an exclusive hinge design which provides zero heel gap.

Open, dust covered or hermetically sealed, the MG is available with contact arrangements up to 4 Form C (4PDT). It is rated for ambient temperatures of −55°C to +85°C. A high-temperature version with a range of −65°C to +125°C will soon be available. Write or wire today for complete specifications and delivery information.

MG RELAY

TERMINALS:
Open Relay: Pierced Solder Lugs.
Contacts: Two #18 AWG wires. Coil: Two #20 AWG wires.
Hermetically Sealed:
Miniature plug-in header with 7, 9 or 14 pins. Multiple Solder header with hook and terminals for three #20 AWG wires.
Polystyrene Dust Cover: Micro Ribbon plug-in type.
Mating receptacle: Amphenol #57-20140 or similar.
INSULATION RESISTANCE: 100 megohms min.
VIBRATION: .065" excursion 10-55 cps. 10g 55-550 cps. upon request.
SHOCK: 30g according to Mil-R-5757C upon request.
TEMPERATURE RANGE: −55°C to +85°C.
WEIGHT: 1.2 ozs. (open) 2.0 ozs. (sealed).
PULL-IN SPEED: Approximately 15 ms at nominal voltage.
DROP-OUT SPEED: Approximately 10 ms at nominal voltage.
CONTACTS: 3/32 silver.
CONTACT ARRANGEMENT: 4 pole, double throw (4 Form C).
COIL POWER: 3 watts max. DC @ 25°C. Continuous duty.

P&B Standard Relays are available at your local electronic, electrical and refrigeration distributors

Potter & Brumfield, inc.
PRINCETON, INDIANA
SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY
Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

Circle 44 on the card.

New Products

(*Continued from page 46A*)

115-volt 60-cycle a-c into high-frequency (38 kc) electric energy and, by means of the transducer, transmits mechanical vibrations of the same frequency into the cleaning fluid. Cavitation, which is a continual rapid build-up and collapse of pressure, is set up, causing very intense scrubbing action. It literally blasts the oil, grease, sludge, carbon, soot, and other contaminants off any part suspended in the cleaning fluid. *Circle* 215 *on the card.*

Headset. The Twinset, a new and improved headset for use with many different kinds of office, laboratory, and communications equipment, can be worn for hours at a time with ease and comfort. Constructed of light, durable Eastman Chemical Products, Inc. Tenite butyrate plastic and bright nickel, it weighs only 1.6 ounces. The set's magnetic receivers rest on the temples, held by a flexible headband which adjusts to fit any head shape or size. An adjustable tone arm from each receiver pipes sound directly into the ear. Butyrate plastic tips on the tone arms fit the ear opening snugly, helping to block out background noise. The Twinset can take a lot of abuse. Its sensitive receivers are sealed against dust and corrosion. Butyrate plastic parts, including the receiver housing and the headband covering, are rustproof and practically unbreakable. Write to Telex, Telex Park, St. Paul 1, Minn. for further information. *Circle* 216 *on the card.*

Subfeeds Added to Panelboards. A subfeed lug kit which makes it possible to add subfeeds to standard *NQO* circuit breaker lighting panelboards has been announced by the Square D Company. This kit is available for both 100 ampere and 200 ampere main lug only panelboards and includes all necessary parts to allow simple conversion of the standard merchandised panelboard. Together with the 3-pole *QO* breaker, the subfeed lug kit allows the majority of panelboard problems to be solved from local distributor stocks. Previously, these requirements necessitated special factory construction. For details, write Square D Company, 6060 Rivard St., Detroit 11, Mich. *Circle* 217 *on the card.*

Selfcontained Closed-Circuit Television Camera. A single unit closed-circuit television camera with associated remote control accessories has been announced by General Precision Laboratory (GPL) Incorporated, 63 Bedford Rd., Pleasantville, N. Y. The vidicon camera, designated as GPL Model *PD-500*, weighs 12 pounds and is completely selfcontained within the camera housing. A remote-control box permitting camera operation from distances up to one mile away is available as an accessory. *Circle* 218 *on the card.*

Rectifier for Aircraft. A smaller high temperature selenium rectifier for aircraft

(*Continued on page 62A*)

Circle 45 on the card. ▶

GENERAL CABLE

PAPER INSULATED
VERSATILE · RELIABLE
POWER CABLES

Manufactured at BAYONNE, N. J. • ST. LOUIS, MO. • EMERYVILLE, CALIF.

This machine forms steel strip into helical coil ducts or channels for use in gas filled or oil filled cable.

Impregnating Tank utilized in the heat-vacuum drying and oil impregnation steps in the manufacture of Paper Power Cable.

Large Cabling Machine used in cabling individually insulated conductors into multiple conductor assemblies.

- **SOLID TYPE**
- **LOW PRESSURE GAS FILLED**
- **LOW PRESSURE OIL FILLED**
- **PIPE TYPE**
  - **High Pressure Gas Filled**
  - **High Pressure Oil Filled**

The excellent operating record over many years and the superior electrical characteristics of paper insulated cable highly recommends its use for all power applications. Paper Power Cable is a predominant type in preference and use for voltages above 5 KV.

General Cable Corporation is equipped with the finest modern facilities for paper taping and with many years of know-how is in a position to supply a high quality product for all low and high voltage applications.

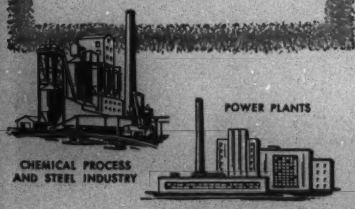
GENERAL CABLE CORPORATION
420 Lexington Avenue, New York 17, N. Y.
Offices and Distributing Centers Coast-to-Coast

for quality and economy... **specify GENERAL CABLE**

Industry looks to

RESEARCH -COTTRELL

for high dust collection efficiencies



To maintain visually clean stacks at all times, industry is turning to the long experience of Research-Cottrell in the design and manufacture of highly efficient Cottrell Electrical Precipitators. We've spent 40 years in solving such problems as nuisance abatement, cleaning gas for subsequent use and recovering materials of value. Write for illustrated bulletin describing a wide range of electrical precipitator applications.

RESEARCH-COTTRELL, INC.

A WHOLLY OWNED SUBSIDIARY OF RESEARCH CORPORATION

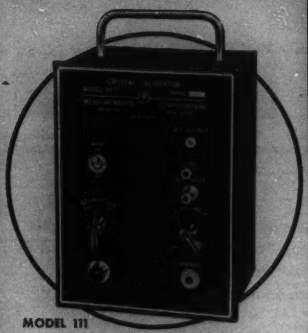
Main Office and Plant: Bound Brook, N. J.

405 Lexington Ave., New York 17, N. Y. • Grant Building, Pittsburgh 19, Pa.

228 N. La Salle St., Chicago 1, Ill. • 111 Sutter St., San Francisco 4, Cal.

▲ Circle 55 on the card.

CALIBRATOR



MODEL 111

Measures and checks frequency of signal generators, transmitters, receivers, etc., where high degree of accuracy is essential.

Frequency Range
Model 111—250 Kc to 1000 Mc
Model 111-B—100 Kc to 1000 Mc
Frequency Accuracy ± 0.002%
Write for Bulletin

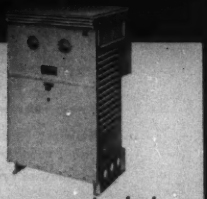
Laboratory Standards

MEASUREMENTS CORPORATION

BOONTON • NEW JERSEY

Circle 56 on the card.

NEW CHRISTIE SILICON POWER RECTIFIERS



For Top Reliability

- A standard line from 30 to 1000 amps
- Closely regulated by magnetic control
- Voltages: 8-16-32-36
- Stationary or Mobile Types
- For Missile, Aircraft, Lab & Factory

Write for Latest Bulletins on *Silicon & Selenium* Power Rectifiers

CHRISTIE ELECTRIC CORP.

Dept. EE, 3410 W. 67th St., Los Angeles 43

Over a Quarter Century of Rectifier Manufacturing

Circle 57 on the card.

New Products

(Continued from page 48A)

use has been developed by the Components Division, International Telephone and Telegraph Corporation, 100 Kingsland Road, Clifton, N. J. The rectifier, model *293M1725*, meets and exceeds *Mil-P-7212B* and large quantities are already being procured by the U. S. Air Force for use in the *B-52* bomber. The rectifier is a 6-phase, full-wave unit with a rating of 100 amperes, 28 volts. It is designed to operate at 125 C ambient temperature. It weighs only 5.5 pounds and has basic dimensions of 5 inches by 6 inches by 6 inches. This compares with previous models of identical rating which weigh up to 8.8 pounds and measure 6¼ inches by 7¼ inches by 7¼ inches. The rectifier utilizes a unique, double-sided cell design which permits the reducton in size and weight. *Circle 219 on the card.*

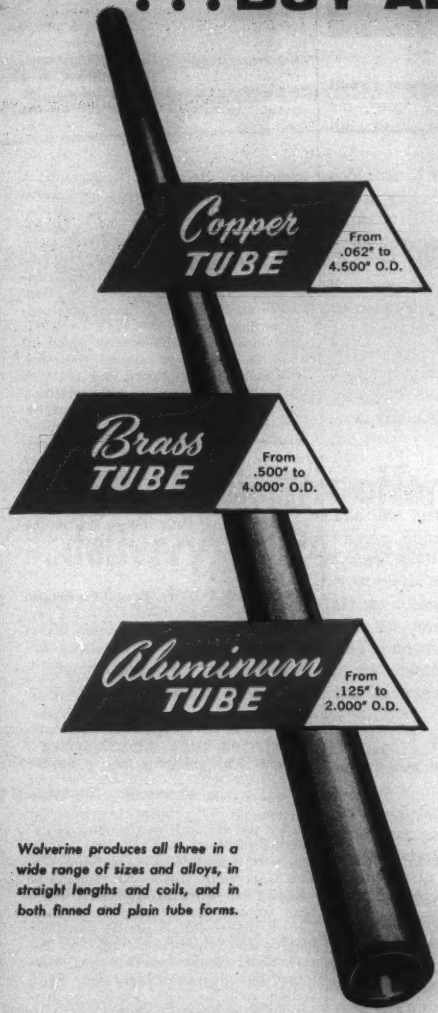
Microfilm Viewer. Engineering drawings, maps, medical case histories, specification sheets, personnel records, legal-size, and other documents on microfilm can be viewed conveniently or can be readily reproduced in the viewer-printer announced by the Filmsort Division, Dexter Folder Co., 50 So. Pearl St., Pearl River, N. Y. A redesign of the unit known as "The Examiner," the new machine is the largest of the desk-top models. Its viewing screen is 14 inches by 14 inches and the lens will provide magnifications of 15, 20, 24, 30, and 43 times. The screen is slightly tilted for reading convenience at seating level. Redesign features include a 6-inch reduction in over-all height, and increased lamp wattage for greater screen illumination and higher reproduction resolution. The viewing screen area is hinged so that it is readily opened to serve as the exposing area for making enlarged prints. *Circle 220 on the card.*

Seal for Liquid Oxygen. New liquid seals of Morganite are ideal for service in equipment handling liquid oxygen. These seals function efficiently in all of the diverse types of liquid oxygen systems in use today. For complete information, readers are invited to write the manufacturer: Morganite Incorporated, 3302-48th Ave., Long Island City 1, N.Y. Please address inquiries to the attention of the Carbon Specialties Division. *Circle 221 on the card.*

Punched Card Reader. This reader, called Connect-O-Matic, developed for Cinch Mfg. Corp., 1026 S. Homan Ave., Chicago 24, Ill., is a simplified circuit switching device having great versatility, which provides a substitute for patch cord panel systems used in the changing of circuit connections at random intervals. It features a molded block with 400 floating contacts passing from one face to the other. This block is sandwiched between two printed wire boards having strip conductors in various grill-like formations. The contacts make connections between groups

(Continued on page 72A)

. . . BUY ALL 3 FROM 1



Wolverine produces all three in a wide range of sizes and alloys, in straight lengths and coils, and in both finned and plain tube forms.

When you're in the market for copper, brass or aluminum tube you can save time by making Wolverine your "buy" word. You obtain the product you need—made the way you want it—packaged to your exact requirements—and delivered when you want it.

Anticipating customer demands, and having the equipment, know-how and skilled employees needed to meet those demands, are all part of Wolverine's Tubemanship program. Wolverine customers can avail themselves of a wide range of specialized services in addition to various types of tubing.

Wolverine, for example, maintains complete fabrication facilities—is able to fin, spin, bend, coil, flare, expand, bead, drill, pierce—in short to do just about anything tubing customers require. From Wolverine's constant research program has come tubing specially designed to help solve the problems of such complex industries as refining, petro-chemical and petroleum processing, refrigeration and air conditioning—to name but a few.

▲ ▲ ▲

For your convenience Wolverine maintains sales offices in 33 American cities. Complete information can be found in Wolverine's General Products Catalog. Write for your copy—TODAY.

BUY AMERICAN

CALUMET & HECLA, INC.
CALUMET DIVISION
WOLVERINE TUBE DIVISION
FOREST INDUSTRIES DIVISION
CALUMET & HECLA OF CANADA LIMITED
CANADA VULCANIZER AND EQUIPMENT COMPANY LIMITED

WOLVERINE TUBE

Division of Calumet & Hecla, Inc.

1724B SOUTHFIELD ROAD • ALLEN PARK, MICH.

Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

5758

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES

EXPORT DEPT., 13 E. 40TH ST., NEW YORK 16, N. Y.

The **GENERAL** *Idea*

ON ENGINEERING CAREERS

GENERAL SYSTEM

What?—digital computer techniques used in telephony?

Ferrite cores and other promising memory devices are being adapted for use in electronic telephone switching systems at General Telephone Laboratories. (Actual size [6] *)*

The engineer with a background in digital computer work is often surprised to find that, (A) the telephone industry offers a real opportunity for his specialized knowledge, and that (B) in telephony he is apt to face an interesting new challenge in terms of circuitry and high-speed switching operations.

At General Telephone Laboratories, we are making extensive use of computer technology to develop the telephone systems of tomorrow . . . as well as to solve the everyday problems of circuitry in existing systems.

We are, for instance, engaged in extensive research and development work on all-electronic, transistorized switching systems. An important phase of these projects involves memory devices. Existing techniques, such as ferrite cores, will require quite a lot of adaptation to meet the demands for speed imposed by electronic telephone switching. We are exploring every known technique of memory storage, including ferrite cores and photo memory devices, for both temporary and semi-permanent applications.

Electronic circuit design and packaging is another area where computer experience finds a valuable outlet at General Tel Labs. In logical circuit design as applied to telephony, the engineer can apply his creative abilities to the fullest extent.

If the foregoing gives you some idea that telephony, far from being static, is one of the truly dynamic industries from an engineering standpoint, that's the way we intended it. At General Telephone Laboratories, our work ranges far beyond the telephone as such. Providing R&D support for Automatic Electric Company and the other affiliated manufacturing units of the General Telephone System, we work in the entire field of Communications and Controls.

Notes on growth . . .

Right about the time you read this, the General Telephone System will add its 3 millionth telephone, an increase of nearly 100% since 1950! Of interest to the engineer looking to his future is the fact that the General System's growth is rooted in one of the most stable businesses in our economy. This is a fact well worth considering, if your present job has more alleged glamour than stability.

You're invited . . .

General Telephone Laboratories is expanding to keep pace with the healthy growth of the General Telephone System—not only its operating companies but its far-flung manufacturing operations as well. If you are qualified for important R&D assignments in electronics, electrical, electro-mechanical or mechanical engineering, we have a career opening that provides the hard-to-find combination of challenge and security. We'll be happy to give you the details about your specific opportunities. Write to Mr. Robert Wopat, President, General Telephone Laboratories, Northlake, Illinois.

GENERAL TELEPHONE LABORATORIES

INCORPORATED

NORTHLAKE, ILLINOIS

A member of the General Telephone System—One of America's great communications systems

New Products

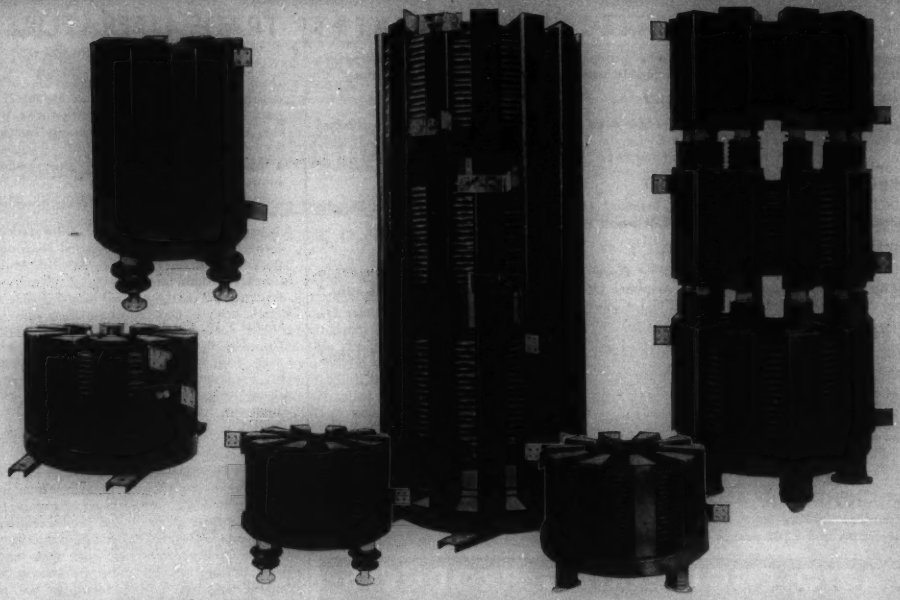
(Continued from page 62A)

of conductors on one of these printed wire boards to other groups on the other, except where a card interposes an insulation. Perforations in the card permit connections to be made where desired, and to be changed by substituting a new card. Ordinary 3-inch by 5-inch cards are used, containing the 400 hole positions, in a 20 by 20 array. For further information contact the company. *Circle 222 on the card.*

Cathode-Ray Recording Oscillograph. A recording oscillograph which can record simultaneously up to 16 channels of phenomena at frequencies at high as 100,000 cycles per second with exceptional clarity on a single 8-inch-wide record, is now available from the Miller Division, Consolidated Electrodynamics Corporation. Known as the *CR-1B* cathode-ray recording oscillograph, the unit is a complete, high-precision recording system which includes its own power supplies, preamplifiers, deflection amplifiers, and recorder. Unusually stable circuitry and a precision optical system combine to provide precise, drift-free signals recorded as traces comparable to those obtained on galvanometer-type recording oscillographs. Further information appears in Bulletin No. *1589*, available from Consolidated Electrodynamics Corporation, 300 N. Sierra Madre Villa, Pasadena, Calif. *Circle 223 on the card.*

Radio Tower Lighting Transformer. Insulated radio tower lighting transformers employing larger diameter porcelain sleeves are on the market. These insulated transformers, now in operation at various United States Army Air Force and Navy installations around the world, were designed primarily to permit use of insulated towers for operation at high radio frequency voltage. Operating an insulated tower at high voltage makes it possible for a single tower to supplant the large flat-top type formerly used. These transformers are independent of radio frequency and are made in a number of different sizes. Some are of the open toroidal type. The transformers have primary as well as secondary taps so that they can be used for a wide range of output. Where both steady and flashing lights are required, condensers are placed across the flashing load to prevent voltage drop. For very high voltage operation, the transformers are oil insulated. For more information, write to A. O. Austin Co., Barberton, Ohio. *Circle 224 on the card.*

Television Recordings Tape. The world's first commercially available recording tape capable of recording television sight and sound has been announced by Minnesota Mining and Manufacturing Co. (3M), 900 Rush St., St. Paul 6, Minn. The new magnetic tape is called "Scotch" brand video recording tape No. *179. Circle 225 on the card.*



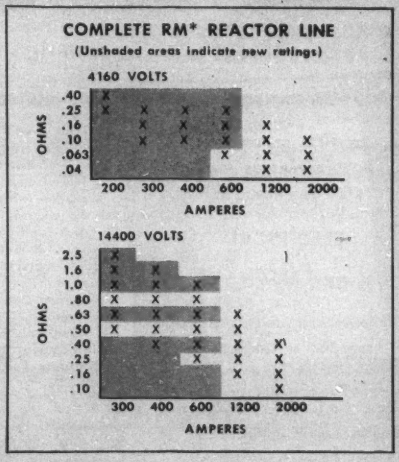
General Electric offers 8% lower prices, faster delivery in 24 new ratings of RM* reactors

8% PRICE REDUCTION and two to three weeks shorter shipment, possible for years with G.E.'s Repetitive Manufacture (RM) reactors, are now available in 24 new ratings up to 2000 amperes in both the 4160- and 14,400-volt classes. This means major savings in your most-required protective ratings.

RM REACTORS HELP PROTECT COSTLY EQUIPMENT and reduce system expansion costs by helping limit short-circuit currents to the capacity of other components. For this reason, G.E.'s reactor ratings are designed to coincide with the standard short-circuit ratings of switchgear, regulators, and other system equipment.

OPPORTUNITIES FOR SAVINGS exist throughout your system. Feeder protection, bus sectionalizing, bus synchronizing, and neutral grounding are only a few of the applications where G.E.'s complete line of reactors can help reduce equipment investment. Full details are available from your G-E Sales Engineer or from Section 422-38, General Electric Co., Schenectady 5, N. Y.

*Repetitive Manufacture



Progress Is Our Most Important Product

GENERAL ELECTRIC

For more information circle 66 on reader service card.

TELEPHONE AND TELEGRAPH EQUIPMENT

Radio Engineering Products is currently producing a number of types of equipment, electrically and mechanically interchangeable with standard Bell System apparatus.

CARRIER-TELEPHONE EQUIPMENT

C5 Carrier-Telephone Terminal (J68756). A kit for adding a fourth toll-grade channel to existing C systems is available. • C1 Carrier-Telephone Repeater (J68757) • 121A C Carrier Line Filter • H Carrier Line Filter (X66217C).

CARRIER-TELEGRAPH EQUIPMENT

40C1 Carrier-Telegraph Channel Terminal (J70047C) • 140A1 Carrier Supply (J70036A1, etc.) • 40AC1 Carrier-Telegraph Terminal.

VOICE-FREQUENCY EQUIPMENT

V1 Telephone Repeater (J68368F) • Power Supply (J68638A1) • V1 Amplifiers (J68635E2 and J68635A2) • V3 Amplifier (J68649A) • V-F Ringers (J68602, etc.) • Four Wire Terminating Set (J68625G1) • 1C Volume Limiter (J68736C).

D-C TELEGRAPH EQUIPMENT

16B1 Telegraph Repeater (J70037B) • 10E1 Telegraph Repeater (J70021A) • 128B2 Teletypewriter Subscriber Set (J70027A).

TEST EQUIPMENT

2A Toll Test Unit (X63699A) • 12B, 13A, 30A (J64030A) and 32A (J64032A) Transmission Measuring Sets • 111A2 Relay Test Panel (J66118E) • 118C2 Telegraph Transmission Measuring Set (J70069K) • 163A2 Test Unit (J70045B) • 163C1 Test Unit (J70045D).

COMPONENTS AND ACCESSORIES

255A and 209FG Polar Relays • Repeating and Retard Coils, several types • 184, 185, 230A and 230B Jack Mountings.

RADIO ENGINEERING PRODUCTS
1080 UNIVERSITY ST., MONTREAL 3, CANADA
TELEPHONE University 6-6887
CABLES RADENPRO MONTREAL

▲ Circle 67 on the card.

DESIGN

ENGINEERS

WANTED

ELECTRICAL DISTRIBUTION
APPARATUS
POLE LINE HARDWARE

ELECTRICAL

CIVIL and MECHANICAL

With some experience in Electrical Distribution Transmission or Communication Pole Line Design

Old established company undergoing expansion offers splendid opportunity for advancement. Excellent working conditions. Communications strictly confidential.

WRITE
BOX 268
CHICAGO 50, ILLINOIS

INSTRUMENTATION ENGINEER OR PHYSICIST

Applicant should have a background of electrical engineering, physics, or engineering physics with additional education or experience in instrumentation. The work involves co-operation with Research, Development and Engineering Groups in a new, well-equipped laboratory.

Fields of interest are the use of electronics in experimental research, electrical measurements and instrumentation, radio-activity measurements and general engineering physics techniques.

If interested, write Mr. J. J. Rostosky, Linde Company, Division of Union Carbide Corporation, P. O. Box 8237, Indianapolis 24, Indiana.

Linde UNION CARBIDE

"Linde" and "Union Carbide" are registered trade-marks of UCC

TRADE LITERATURE

Data Processing Brochure. A new brochure describing the Beckman Model *112* data processing system is announced by the Systems Division of Beckman Instruments, Inc. The 8-page brochure describes a practical data system for the process industries. Detail is given in the brochure outlining the economies of automatic data processing in the present well-instrumentated plant. For further information contact: A. M. Johnson, Systems Division, Beckman Instruments, Inc., 325 No. Muller Ave., Anaheim, Calif.

Small Tool Catalog. A 184-page Catalog No. *216* describes and illustrates small tools and precision equipment designed for work on small instrument parts and allied uses. Free to rated companies, request on letterhead from C. & E. Marshall Co., Box 7737, Chicago 80, Ill.

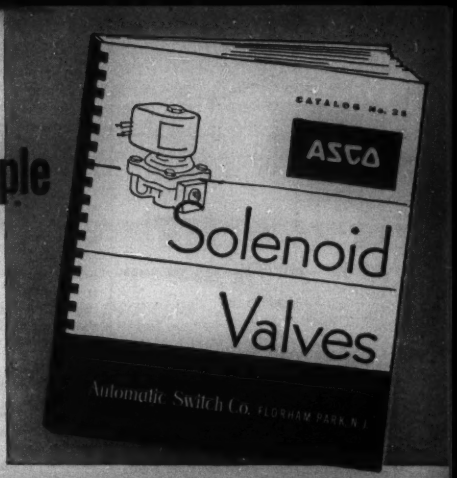
Using Tomorrow's Engineering Today. How to make use of tomorrow's engineering today is brought out in information included in the latest brochure now being offered by the Teller Company, Butler, Pa. Competition for future sales may well depend on advanced and creative engineering today, the brochure points out. What these responsibilities are and how they fit into the future is shown graphically in the brochure which cites case histories of successful engineering achievements from preliminary management action through design to sales. Detailed information is given describing such services as machine design and fabrication, equipment layout, equipment and material procurement, equipment installation, training of personnel, and engineering consultation. Copies of the new brochure may be obtained by writing the Teller Company, Butler, Pa.

Submersible Pump Cable Brochure. A 4-page brochure describing the various types of Essex submersible pump cable is being offered by the Essex Wire Corporation, 1601 Wall St., Fort Wayne, Ind. Included are descriptions of standard submersible cable, motor lead wire, heavy duty submersible cable, and drop cable. Complete specification charts give details of available sizes, conductors, strandings, conductor insulations, jacket thicknesses, nominal diameters, and net weights per 1,000 feet.

Printed Circuit Soldering Manual. Just published is a 12-page technical brochure titled "Printed Circuit Soldering," said to be the first serious work of its kind in this rapidly expanding new field. The new booklet describes the types of fluxes suitable for printed circuit soldering and also covers such matters as temperatures, procedures, alloys, and contaminations. Copies may be obtained without charge by writing direct to Kester Solder Company, 4201 Wrightwood Ave., Chicago 39, Ill.

(Continued on page 78A)

ASCO makes Solenoid Valve selection simple

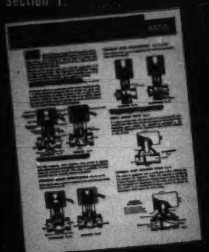


Comprehensive Design Engineering Data Now Available
Keys Proper Solenoid Valve to Application

Specifically designed to make the selection of solenoid valves simple, the ASCO Valve Catalog gives you the most comprehensive engineering data available to aid you in your solenoid valve selection.

Here are 114 pages of up-to-date valve information. These pages incorporate detailed engineering sections. Finding the proper valve for your particular application is made easy by a simple *master index* which leads you to a *separator* where you will find all the valves of the type you require. Each *separator* has a more detailed *index* which will enable you to turn right to the *valve bulletin* needed to meet your particular requirements.

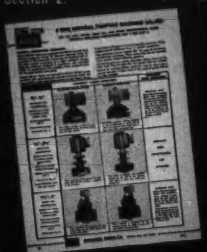
Section 1.



GENERAL ENGINEERING INFORMATION

Expanded engineering data with diagrams, gives valve construction, operating principles, features. With nomographs using Cv ratings for valve sizing.

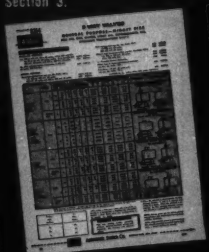
Section 2.



2-WAY VALVES

Covers all 2-way valves of the fully automatic type for a wide range of pipe sizes and pressures.

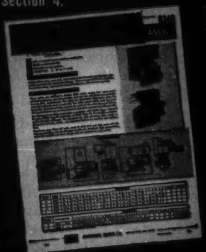
Section 3.



3-WAY VALVES

Detailed information on fully automatic valves for pilot control of diaphragms or cylinders, or for diverting flow in pipelines.

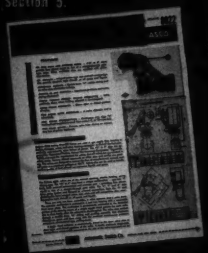
Section 4.



4-WAY VALVES

Fully automatic types covered. Both single and dual solenoid construction for general purpose and J. I. C. requirements.

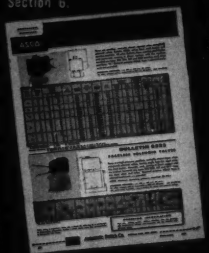
Section 5.



MANUAL RESET VALVES

2 and 3-way solenoid valves for safety shut-off applications.

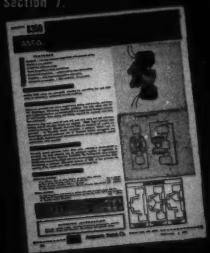
Section 6.



CORROSION RESISTANT VALVES

Includes 2 and 3-way solenoid valves for handling corrosive gases and liquids. Section incorporates a selection guide chart.

Section 7.



SPECIAL PURPOSE VALVES AND ACCESSORIES

Special purpose equipment: waterproof and explosion proof solenoids, laundry valves, cylinders, etc.

Section 8.

NUCLEAR VALVE DATA

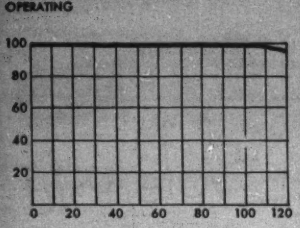
Shows ASCO specialized solenoid valve designs for nuclear, guided missile, Navy and dispensing applications.

You may order the complete catalog or individual sections or bulletins. You will find easy to use return reply cards in each catalog for ordering additional literature. Also available is the Electromagnetic Control Master Catalog 57-S or any one of the six sectional Catalogs covering Automatic Transfer Switches, Remote Control Switches, Contactors, Relays, Solenoids or Electric Plant Controls.

Any of these important engineering reference aids may be obtained by writing Automatic Switch Company — *on company letterhead only please.*

Automatic Switch Co.
50-K Hanover Road, Florham Park, New Jersey
Frontier 7-4000

ASCO



If you want reliable transformers

..don't overlook this old solution

Right now, you demand more from transformers than ever before. You must have high reliability, even at extreme altitudes, and you need smaller lighter units.

Used, and *proved*, for decades, oil-encased transformers should not be forgotten in a search for new methods.

Everyone knows the advantages: effective convection of heat, excellent insulating properties, complete insurance against hidden leaks. Oil-*sealed* types (with a nitrogen bubble) are good, light, high-altitude transformers. Gas-free oil-*filled* types (with a bellows to allow for heat expansion) withstand very high voltage stresses. Except in the smallest sizes, they save space, too.

You can place several high voltage units close together in a single oil-filled case, and save case weight. Those connections moved inside the case no longer need large insulators. Even the units themselves can be smaller. This all adds up—particularly in high altitude service—to interesting savings in space and weight.

We make all sorts of transformers and special assemblies for the communication industry: encapsulated, cast in epoxy or foam, and just potted in pitch. But oil transformers still have an important place.

Whatever type you need, we'll be glad to hear from you. Our facilities in design, production, and quality control are at your service. Our experience, too.

CALEDONIA

ELECTRONICS AND TRANSFORMER CORPORATION

Dept. EE-11, Caledonia, N.Y.

In Canada: Hackbusch Electronics, Ltd.
23 Primrose Ave., Toronto 4, Ontario

Circle 69 on the card.

Trade Literature

(Continued from page 74A)

Literature on Thermostat Accessories. A variety of modern accessories for electric thermostats and limit controls manufactured by Robertshaw-Fulton Controls Company, are described in a recently published 4-page bulletin. Bulletin *RT-819* contains detailed drawings and diagrams of available thermostat cases, devices for adjusting temperature controls, mounting brackets, and stuffing boxes. The informative bulletin *RT-819* is available upon request, without obligation, from Robertshaw-Fulton Controls Company, 110 E. Otterman St., Greensburg, Pa.

Instrument Catalog. The John Fluke Short-Form Catalog No. *C-57* listing all instruments in production, and those which will be released to production, is now available for mailing. Contact your local representative or write directly to John Fluke Mfg. Co., Inc., 1111 W. Nickerson St., Seattle 99, Wash.

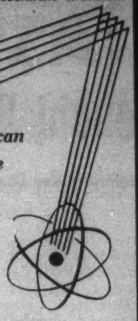
Hydraulic Turbine Bulletin. A 48-page bulletin describing the three principal types of hydraulic turbines has been released by Allis-Chalmers Manufacturing Company. The bulletin's partial list of units, totaling nearly 14 million hp, includes some of the company's largest installations in each category with cross sections and other engineering information. Illustrated reference is made to such recent projects as Kemano, Noxon Rapids, Shepaug, St. Lawrence, and Hiwassee. Never before included in any general hydraulic turbine bulletin is a section on the reversible pump–turbine, a major contribution to better present-day and future development of water power. Copies of "Hydraulic Turbines and Auxiliaries," Bulletin *02B7301A*, are available on request from Allis-Chalmers Manufacturing Company, Milwaukee 1, Wis.

Silicone Molding Compound Folder. A brochure exclusively devoted to silicone molding compounds has been published by Dow Corning Corporation, Midland, Mich. The low thermal conductivity, superior electrical properties, and high temperature strength-to-weight ratio of these materials are discussed, along with charts, graphs, and field examples. Physical and electrical properties of *Mil-M-14E*, which these materials are designed to meet, are also listed, both for Type *MSI-30* and Type *MSG*. The four pages are in three-color printing. Code *#7-603*. For further information contact R. S. Argyle or J. H. O'Neill at the company.

Relay Catalog. This 36-page catalog lists thousands of relays made by all leading relay manufacturers. Prices and model numbers are included for easy ordering. Almost every relay listed can be obtained on 24-hour delivery from stock. For a copy of this new relay catalog write Relay Sales, Box 186-EN, West Chicago, Ill.

(Continued on page 85A)

ELECTRICAL ENGINEERS



you can help put the first nuclear powered plane in the air

at the AIRCRAFT NUCLEAR PROPULSION DEPARTMENT OF GENERAL ELECTRIC

Think of contributing to one of the most important events in aviation history . . . helping bring out an engine that has unlimited range . . . where fuel can be measured in pounds per day rather than thousands of pounds per hour.

Yes . . . an engineer can make a name for himself here—and he doesn't need previous nuclear training to do it.

If you have from 1 to 5 years experience and enough flexibility of mind to apply your technical knowledge to new fields—you can start work immediately in project areas like these:

- **CONTROLS AND INSTRUMENTATION** (pneumatic, hydraulic, electrical, magnetic, servos)
- **PRINTED CIRCUIT DESIGN**
- **ENVIRONMENTAL TESTING FOR REACTORS, TURBOJET ENGINES AND ASSOCIATED POWER PLANT EQUIPMENT**
- **ANALOG SIMULATION**

Your conventional skills will be fully utilized, you'll learn new ones on the job—either through consultation with experts, courses in nuclear technology at the plant, or graduate study on a 100% Tuition Refund Plan.

FREQUENT MERIT REVIEWS
OUTSTANDING BENEFITS
RELOCATION EXPENSES PAID

Choice of two locations:
CINCINNATI, OHIO
IDAHO FALLS, IDAHO

PUBLICATION OF TECHNICAL PAPERS IS ENCOURAGED

Write in confidence, stating salary requirements, to location you prefer:

J. R. Rosselot, P. O. Box 132
Cincinnati, Ohio

L. A. Munther, P. O. Box 535
Idaho Falls, Idaho

GENERAL ELECTRIC

Trade Literature

(Continued from page 78A)

Metalworking Bibliography. A selected bibliography from the library of Aluminum Company of America has been made available to designers and design engineers in the metalworking industry. All available Alcoa literature and motion pictures of possible interest to designers are discussed in "Bibliography of Information about Aluminum for the Designer." The new listing is available by writing room 799, Alcoa Building, Mellon Square, Pittsburgh 19, Pa.

Metal Strip Plating Process Described. A unique process developed by Sylvania Electric Products Inc., Parts Division, 12 Second Ave., Warren, Pa., heralds new applications for plated strip throughout the electrical-electronics industry. The new process, which permits plating of a wide variety of base metals with common plating materials, provides a high quality, low cost replacement for clad materials traditionally used in the fabrication of various electronic tube parts. The high degree of plating uniformity made possible by the new process may eliminate the need for plating formed metal parts where good electrical contact and a high degree of solderability are desired. Plated strip permits application of new assembly techniques previously impossible due to the need for plating formed parts after fabrication. Applications of the new process are described in a product bulletin "Plated Metal Strip" available from the company.

Wind-Recording System Literature. Recommended primarily for fixed-station use on standard power lines, a Beckman & Whitley wind-speed and wind-direction recording system is described in a piece of literature identified as Form *F-457*. One of many typical equipment installations is illustrated, with emphasis on atmospheric-pollution application. The text includes further suggestions concerning applications in plant-site investigation, military studies, and forestry and agricultural control by organizations concerned with meteorology, aviation and missiles, smelting and refining, power generation, environmental engineering, reactor operation, and general research and engineering. For further information contact Beckman & Whitley, Inc., 909 E. San Carlos Ave., San Carlos, Calif.

Products and Facilities Brochure. A new two-color, 12-page brochure on the products, capabilities, and facilities of the new Magnetics Division of Servomechanisms, Inc., is now available. Detailed information is provided on the facility which designs and manufactures custom magnetic components such as transformers, magnetic amplifiers, filters, converters, reactors, discriminators, and networks. The brochure may be obtained by writing Servomechanisms, Inc., Magnetics Division, 1000 W. El Segundo Blvd., Hawthorne, Calif. Attention: William Miller, Sales Manager.

careers in peaceful applications of atomic energy

ENGINEERS–
SENIOR POSITIONS

Diversified work in overall reactor analysis

SYSTEMS/CONTROL–ANALYSIS

Qualifications: BS, MS, PhD in EE, Physics or Nuclear Engineering. 1-3 yrs. experience reactor or control systems evaluations, or related instrumentation.

Duties: Direct and perform stability analysis. Develop power plant control systems. Prepare system specifications, and perform nuclear hazard evaluation of reactor systems.

REACTOR ANALYSIS

Qualifications: BS, MS in Engineering. Prefer minimum 4 years' experience in related field.

Duties: Analyze, direct engineering efforts on advanced reactor plant design. Special emphasis on overall plant control, steam plant operation and economic analysis of integrated reactor steam plants.

Write: Answer will be prompt, confidential.

ATOMICS INTERNATIONAL
A DIVISION OF NORTH AMERICAN AVIATION, INC.

Mr. G. W. Newton, Personnel Office, Dept. EE-11
21600 Vanowen Street, Canoga Park, California
(In the Suburban San Fernando Valley, near Los Angeles)

CLASSIFIED ADVERTISING

For help and situations wanted, $2.00 per line, minimum 5 lines, maximum 30 lines. Sale and purchase of used machinery, etc., $2.50 per line, not available to dealers. Address orders to: Classified Section, ELECTRICAL ENGINEERING, 6th Floor, 33 West 39th Street, New York 18, N. Y.

When answering an advertisement, send all replies to box number specified, c/o ELECTRICAL ENGINEERING, 6th Floor, 33 West 39th Street, New York 18, N. Y., unless other address is given.

Positions Open

PROFESSOR OF ELECTRICAL ENGINEERING—to teach and do research in the field of communications. Should have Ph.D., teaching and research experience. $9,400-$12,000. Write Box 468.

ELECTRICAL ENGINEER—Electrical Engineer interested in electrical design of power plants or industrial plants. Experience not required. Excellent opportunity with consulting engineering firm in Middle West. Liberal benefit plans and good working conditions. Send resume of education and experience with statement of salary requirements to: Box 492.

GRADUATE ASSISTANTSHIPS are available at a university in the Southeast for September 1958. Assistants may obtain the Master of Science degree in Electrical Engineering in twelve months. Tuition free. Box 569.

ELECTRICAL DESIGNERS—TOP SALARY Scheduled overtime at time and one-half rates. Immediate openings, permanent positions, paid holidays and vacations. Experience required in Power Plants and Industrial Buildings. MARBARRY CORPORATION, 120 Greenwich Street, New York 6, New York. REctor 2-3749.

ASSOCIATE PROFESSOR ELECTRICAL ENGINEERING to teach graduate and undergraduate courses. Should have Ph.D., be 30 to 40 years old and be interested in one or more of the following: Electromagnetic Field Theory, Electron Devices, Network Analysis Servomechanisms. Salary $9000 for 9 months. Opportunities to augment this through contract research to the extent of additional $4500. Box 573.

MECHANICAL ENGINEERS. Graduate mechanical engineers interested in electric production by steam generation. Experience desirable, not required. Male. Age 22-40. Excellent opportunity to grow with a rapidly expanding electric utility in the Middle Atlantic States area. Salary between $9,000 and $10,000. Please submit resume. Box 574.

MIDDLE ATLANTIC STATE. GRADUATE ELECTRICAL ENGINEER as Superintendent with intimate knowledge of Generation, Distribution, and Metering. Municipal, 20,000 population. Steam. Furnish resumé and salary requirement. Box 579.

ELECTRICAL ENGINEERING TEACHING POSITIONS—Excellent opportunities are available to properly qualified personnel in new department. Location is in the midwest at a medium size university. Salary, rank and teaching opportunities are excellent. Appointments are available beginning, February, 1958 and September, 1958. Send complete resume to Box 581.

ELECTRICAL ENGINEER—As Distribution Engineer, for midwest municipal electric and water utility. Experience in design, planning and operation of 2400/4160 volt distribution lines. Excellent opportunity for advancement. Age 35-45. Salary commensurate with qualifications and experience. Box 584.

SENIOR BUILDING ELECTRICAL ENGINEER—$7500 to $9090 in five increments. New York State Government Department of Public Works. State residence not required. Full Civil Service status after examination. Requires professional engineer's license and profesional electrical engineering experience preferably in the design, preparation and checking of electrical layouts. For further information write to Box 37A, Recruitment Unit, N. Y. State Dept. of Civil Service, 39 Columbia Street, Albany, N. Y.

SALES ENGINEER—Work out of New York office of leading electric motor control manufacturer. Sales experience and engineering degree required. Give full particulars in writing on qualifications, personal history and salary requirements to Box 585.

GENERAL ELECTRIC ADVANCED ELECTRONICS CENTER at Cornell University has openings for experienced electronic engineers and physicists. As the Advanced Engineering Component of the Light Military Electronic Equipment Department, the Center is responsible for Applied Research and Advanced Development of Airborne Electronic Equipment. Current work at the Center includes Electronic Warfare, Radar, Communications, Data Processing, Weapons Systems Engineering, Proximity Fuses, Magnetic Amplifiers, Human Engineering, Infrared and Transistors. Replies stating education, experience and salary requirements should be addressed to Dr. Paul Doigan, General Electric Company, Advanced Electronics Center at Cornell University, Ithaca, New York. All replies will be kept confidential.

Positions Wanted

GERMAN ELECTRICAL ENGINEER, 32, desires permanent post in America. 2½ years experience with U. S. Army European Hqs. in design, specification and utilization of power plants, distributions and installations of buildings and airport. Immigration visa is available in short time if U. S. or Canadian employment is available. Will pay own passage. Bruno Bauer, 4 Lenaustrasse, Heidelberg, Germany.

SALES ENGINEER—Electrical instrumentation, electrical equipment, and electronics. Broad experience in sales application. Interested in connection with progressive organization, sales to industrials and utilities. Age 56. Location open. Box 582.

NOTE: Closing date for material to be set in the classified advertising column, as well as cancellations for running ads, must be received not later than the twenty-fifth of the second month preceding; i.e., November 25th for the January issue.

ELECTRONICS EXECUTIVE with diversified experience in Engineering and Management in Latin America. Desires Plant Management or similar responsibility requiring initiative, growth and ability in Mexico or Latin America. MSEE and Languages degrees, professional societies membership. Married. Available December 1957. Box 583.

COMMUNICATIONS ENGINEER—Established reputation systems engineering, marketing management level in telecommunication networks and industrial electronics. Strong development background VHF, microwave communications, radar, telemetering. Extensive government and commercial experince U. S., Latin America, Europe. Seeks position staff level or consultant engineering sales U. S., Europe. Box 586.

A.I.E.E. TRANSACTIONS wanted to buy for cash back volumes and sets also other scientific and technical Journals—E. E. ASHLEY, 27 East 21st Street, New York 10, New York.

ENGINEERS', SCIENTISTS' AND TECHNICIANS' RESUMES our specialty. Multilithed reproductions—$3.80 per page 50 copies—$4.80 per page 100 copies. Mail orders add 35¢. Write for "How to Write Your Resume" with sample guide $1.50 postpaid. Orville E. Armstrong & Co., 55 W. 42nd St., Dept. E, New York 36, N. Y.

DU PONT

OFFERS LONG-RANGE

CAREER OPENINGS

ELECTRICAL ENGINEER

Position requires a minimum of 8-10 years industrial experience in power generation and distribution, electrical drive control and process applications covering the design, selection, maintenance and operation of electrical equipment and systems. Successful applicant will consult on the preparation of recommendations concerning plant operating maintenance methods and procedures, analysis and solution of unique manufacturing problems and the conduct of performance and quality tests.

AUTOMATIC PROCESS CONTROL

Position requires broad and detailed experience in research, application, consulting, or design of automatic controls for chemical, mechanical, or aeronautical applications. The successful applicant will provide consulting advice to operating plants and development laboratories on the application of automatic control to new processes and for the improvement of existing processes. Position will require the study of process controllability by analysis of open and closed loops and the measurement of control characteristics of instrument components.

NEW YORK CITY INTERVIEWS

Sun-Mon-Tues-Wed
December 1-2-3-4
For an appointment, please call
Mr. K. S. Marlin, Jr.
PEnnsylvania 6-5877

CHICAGO INTERVIEWS

Sun-Mon-Tues-Wed
December 8-9-10-11
For an appointment, please call
Mr. K. S. Marlin, Jr.
WAbash 2-7992

or you may send complete resume, including details of education and experience, to:
Mr. K. S. Marlin, Jr.
Engineering Department
E. I. du Pont de Nemours & Co., Inc.
Wilmington 98, Delaware

DU PONT
REG. U.S. PAT. OFF.

Better Things for Better Living
...through Chemistry